CHEMICAL WEED CONTROL RESEARCHER:

ALDEN S. CRAFTS

LXVI ATA. 32.5 μg 4 μc 1 DROP LS 4 DAYS. FREEZE-DRIED.
ZEBRINA. TAP WATER CULTURE, ONE MONTH.

Alden S. Crafts and George W. Mason,
New Zealand - August, 1965

CHEMICAL WEED CONTROL RESEARCHER:

ALDEN S. CRAFTS

Introduction by W. A. Harvey

Interviews conducted by:
A. I. Dickman
The Oral History Office
Shields Library
University of California
Davis, California

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The procedures of our oral history projects include not only the tape recording of memoirs but also their transcription, editing, and eventual production in book form. What is presented to the reader is a version of the spoken word, and overt attempts to mask this fact rob the presentation of the intimacy, candor and spontaneity which give each memoir freshness and charm. However, standard and recognized editorial techniques are used to maintain a consistency of style throughout all oral history project publications. Since basically each title is for University archival deposit, such matters as dates, names, places, and scientific terminology must be presented with the utmost precision. Editors will rely on the Chicago *Manual of Style* (1969) and the project's own style sheet to maintain an optimal printed version of the spoken word.

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INTRODUCTION

Alden Crafts has been a major force in the development of the discipline we now call Weed Science. He came to the Davis Campus following his graduate work in Berkeley as the first staff member employed by any University to work full time on the control of weeds. His background in farming and rigorous academic training in plant physiology provided an ideal basis for his understanding of weed problems from the farmer's viewpoint and the scientific approach to solving these problems.

His early work with arsenical compounds was classic in the involvement of translocation studies, explaining the movement of arsenic in the perennial morning glory as related to soil and environmental conditions. This interest in the scientific approach to what had previously been simple weed control has persisted through all of his research. He was one of the first to carefully study the behavior of herbicides in different soil types which led to better recommendations for field use of the soil-active herbicides.

We should remember that in these early years there were very few useful herbicides and new ones came along only rarely. Alden Crafts was active in the development of all of these - the arsenicals, borax compounds, chlorates, carbon bisulphide and the dinitros.

With the advent of 2,4-D in 1945 a whole new field was open for study, using the background of plant physiology which Alden Crafts knew so well. His own work and that of his graduate students provided an important basis for understanding the translocation and soil behavior of this new class of compounds.

Weed Control by Robbins, Crafts and Raynor was the first publication of its kind in the world and was not only the source of information and the text book widely used in the U.S., but was translated into numerous foreign languages for use overseas. It was truly the impetus for development of scientific study of weeds throughout the world.

Alden Crafts is a prolific writer and his publications have continued even in these retirement years. His active mind recognizes needs and his energy is directed toward providing information wherever possible.

I have known Alden Crafts for more than 40 years. As I review the work of this man I am hard pressed to select his most important accomplishments. They include an enormous amount of research, many publications, a clan of graduate students spread over the world, talks and lectures given world wide, and a friendly advisor to what is now two generations of weed workers.

Perhaps it is the whole of all of these that add up to what I see as a major accomplishment--he made work on weeds scientifically acceptable. As a former president of the American Society of Plant Physiologists and an early president of the Weed Science Society of America, he did more than any other individual to transform weed control into Weed Science.

W. A. Harvey
23 November 1981

DEDICATION

I would like to dedicate this Oral History to my first wife Alice, to my present wife Helen, to my two children Harold and Helen, and to my many students around the world.

Alden S. Crafts

HISTORY OF THE INTERVIEW

I like history. In grade school I was interested in the history of our country. In high school I took ancient history. And during my college years many of our text books gave a brief review of the history of the subject. In my course in the mineral nutrition of plants, taught by D. R. Hoagland, we used E. J. Russell's "Soil Conditions and Plant Growth" as a text book. It introduced the early history of mineral nutrition of plants.

When I attacked the problem of assimilate movement in plants as I entered my graduate years, I purchased the book "Die Stoffbewegungen in der Pflanze" by Ernst Münch and read it from cover to cover. During my early professional years I read Strassburger's "Uber den bau and die Verrichtungen der Leitnngsbahnen in den Pflanzen," which I used in my early review papers on phloem transport.

Soon after my retirement there came from the administration of the Weed Science Society of America the statement that they were establishing an archives in which they hoped to develop a history of weed control and records of the achievements of the founders of the Society. They asked for accounts and descriptions of early experimental work in this newly expanding field.

On November 9, 1973 I mailed to Dr. K. E. Savage of the Southern Weed Science Research Laboratory at Stoneville, Mississippi, a resume of my experiences in weed science to place in their "Archives." I termed it "Recollections of a Weed Controller." It consisted of 88 typed pages and a bibliography of some 158 titles. Copies of this paper were sent to several leaders of our society, and a copy was placed in the archives.

My next effort in writing history resulted in a "History of the Western Weed Control Conference." This I produced in 1978 using the Proceedings of the first fourteen conference meetings, from the first in 1938 to the 14th in 1954. This latter date corresponds with the first meeting of WSSA.

This history I submitted to Dr. R. D. Comes, President of the Western Society and he placed a copy in their Archives. It proved to be too long to publish in their Proceedings.

My next production in the history line was an "Autobiography." This turned out to occupy 205 pages, double spaced and has been completed and sent to my son in Saratoga, California and to my daughter in Arlington, Virginia. My wife Helen first suggested the writing of this autobiography, and she encouraged me in my long days of its production.

I first became aware of the Oral History project when Dr. K. Esau came to Davis with the aim of partaking in an Oral History interview. She came on November 10, 1977 and participated in our Plant Science Colloquium in the Botany Department. I did not hear at the time of the results of her interview, and since have heard that no interview was conducted and apparently she will have no Oral History.

I explained the objective of the Oral History project to my wife and told her that I had considered working up a project for writing such a history covering the weed control work in the Botany Department. She approved the idea and suggested that I talk with people responsible for the work. So, during 1979, I approached Dick Dickman and asked him if he thought that such a history was a worthwhile project. He approved the idea but pointed out that it would require some money, because the finances of the project were depleted.

I asked him how much would be required, and he said that $1500 would get it under way. I discussed this with Helen, and with her consent I wrote Dick a check for that amount. I asked him what was the next move, and he told me to come in next week, prepared for the interview. I went home, took out my autobiography, and abstracted it in the form of notes. I went in on February 13, 1981 and we did the interview with the tape recorder running. We filled one tape and put in a second one which we nearly filled.

Dick had the tapes transcribed, and after some time, I was given the typed material to edit and correct. I knew by this time that Dick was in trouble with lung cancer, and after turning over the corrected transcription of the tapes to Candy Peel for final typing, I did not see him again. I heard of his passing and attended the Memorial Service in the Faculty Club on Friday, September 4, 1981.

The work on the Oral Histories is now in the hands of Sabra Basler, who works under the direction of Don Kunitz. On Monday, September 28, Candy came in with all of the materials of my History and turned it over to Sabra. We are lacking an introduction, a history of the interview, an index, and a bibliography of all of my publications. I have turned over to Sabra the bibliography as it was prepared from my publications which have been bound and presented to the library. Bill Harvey has agreed to write the introduction. This present writing constitutes the history of the interview. The index I will prepare from the manuscripts when they are ready for the printer.

A. S. Crafts
October 1, 1981
Davis, California

BIOGRAPHICAL SKETCH

Alden Springer Crafts

Professor Emeritus, Botany Department

University of California Davis, Davis CA 95616

Agricultural Consultant

Education - Degrees

B.S., UC Berkeley	1927
Ph.D., UC Berkeley	1930
M.S., Oxford England	1957
L.L.D., UC Davis	1966

Career

Post-doctoral year, Cornell Support: National Research Council	1930-31
Sabbatical leave, Harvard Support: Guggenheim Fellow	1938
Sabbatical leave, Puerto Rico Support: Visiting scientist, Puerto Rico Agricular Experiment Station, Rio Piedras	1947-48
Sabbatical leave, Oxford England Support: Guggenheim Fellow Fulbright Grantee	1957-58

Positions

Assistant Botanist UCD	1931-36
Assistant Professor of Botany UCD	1936-39
Associate Professor of Botany UCD	1939-46
Professor of Botany	1946-64
Professor of Botany Emeritus	1964--

Offices held

Chairman, Department of Botany	1948-49
Acting Chairman, Department of Botany	1951-52
Chairman, Department of Botany	1959-63
Delegate, 8th International Botany Congress	1954
Chaired symposia and delivered papers at the 9th, 10th, 11th and 12th International Botanical Congresses	
Chairman, California Weed Control Conference, Fresno	1951
Vice Chairman, Gordon Research Conference	1955
Chairman, Western Section of ASPP	1940-41
President, ASPP	1955-56
President, WSSA	1958-60
Editor, Annual Review P.P.	1956-58

Honors

Charles Reid Barnes Life Member ASPP	1962
Honorary Member WSSA	1964
Honorary Member California Weed Conference	1972
Honorary Member Western Weed Control Conference	1970
Life Member, AIBS	
Fellow, AAAS	
Honorary Member Zoology-Botany Society of Vienna	1965
Delegate, 6th Japan Conference on Radioisotopes	1969
Invited Speaker, 2nd Asian Pacific WCC	1969

Honors

Delegate, IUPAC Symposium, "The Chemical Control of the Human Environment," July, 1969.

Research and Writing

Starting in 1931, I have conducted research in weed science and plant physiology for over 40 years.

In 1942, I co-authored a book called Weed Control with Dr. W. W. Robbins and Mr. R. N. Raynor.

This book was revised in 1952 and again in 1962 at which time I was the senior author.

This book was the predecessor to Modern Weed Control which I published in 1975.

I have authored a total of 10 books and about 150 papers in plant physiology, including 50 on translocation.

Two of my books deal with translocation in plants.

Since 1945, I have conducted research on weed control with 2,4-D, involving its absorption, translocation, mode of action and fate in the soil.

I have appeared in a number of 2,4-D drift cases in the United States Courts as an expert witness.

I. CHILDHOOD IN COLORADO

Dickman: Let's start with your birthplace.

Crafts: Okay, I was born in Fort Collins, Colorado, on June 25, 1897. My father, Henry Alonzo Crafts, was a Maine man who had worked in New York City in the newspaper business and then migrated to Fort Collins where he ran a local paper. My mother, Elizabeth McKinney Dunscomb Bleakley, was the daughter of a second-generation Irish immigrant, a businessman and politician in New York City.

He went to Fort Collins to establish a newspaper; she went there for her health. They met and were married and eventually had six children.

Dickman: Would you name all of your brothers and sisters?

Crafts: My oldest brother was Andrew, the next one was Thurlow, and the next one was Henry. Then I had two sisters, Mary the oldest in the family, and Dorothy, just older than I.

My father tried investment. My mother inherited at her father's death a piece of money that wouldn't be very big in present day terms, but it was considerable money in that time. And my father invested it in real estate. In fact, he went overboard and when the Panic of 1897 came along, the bankers closed in on him and he lost his spirit; he retired to writing. But as a writer, he couldn't quite make it. He couldn't take care of a six-child family.

My memories of Fort Collins were skating on Lindenmeyers Lake. Then an incident where I ate some red currants in our backyard that had been stung by wasps and ripened prematurely. I was in bed and the doctor declared it as cholera morbus; I don't know just exactly what that means, but it was a bad bellyache I guess. I remember the alkali water that ran along the streets in the ditches in front of our house. In the wintertime it would dry up and then in the spring, when the first water came through, it would be very strongly alkaline and if we waded in it our feet would get sore and our skin would crack. I remember the circles in the snow made by the youngsters playing Fox and Hounds.

In 1902, my mother took me to kindergarten and I can remember walking up the front steps and hiding behind her skirts as she introduced me to the kindergarten teacher. But I soon got acquainted and enjoyed the experience of kindergarten.

Elizabeth McKinney Dunscomb Bleakley's high school graduation picture and Henry Alanzo Crafts, Sr. (dates unknown)

Crafts: We had a rather serious occasion during these years. My older brother, Andrew, had a shotgun and he did a lot of hunting. He brought in ducks from the outlying districts. He was sitting on the steps in our living room cleaning that shotgun and there was a loud bang. Apparently, he had forgotten to take the shell out of his gun and the bullets went through a wall and lodged in the back of an oak dresser; my father was just on the other side. If if hadn't been for that oak dresser, he would probably have lost his life.

Now my father had a brother, Uncle Horace, in Oakland, California. And he was quite involved in our moving to California. I can remember just as we were about to go away, my older sister Mary graduated from high school and it was the first time that I had ever been up until midnight. Quite an occasion for a youngster.

And I can remember another situation. The water in the Cache Le Poudre River that came past Fort Collins was hardly fit to drink. They piped water down from the mountains and had a faucet up on the campus of the university. My sister and I used to go up with buckets to bring home drinking water.

Now, in 1903, we had a lot of discussion in the family about moving. Uncle Horace had written my father and suggested that he move his family to California. He thought that there were more opportunities there than there were in the little town of Fort Collins. And so, my mother started packing. We packed up our furniture and she packed a big lunch and we went down and took the train from Fort Collins to Denver. There we took the Santa Fe and went through Pueblo, Santa Fe, Albuquerque, Flagstaff, and Needles, California. It was midspring, and the California poppies and blue lupines were out in profusion.

When we were crossing the Colorado River getting into Needles, I can remember the seat under us, that we were sitting on, got kind of hot and when we got on the other side of the river, they stopped the train and found that we had a hot box right underneath us. They got out and cooled it down with water and put some more grease in the bearing, and then we ran on through to Richmond.

Now, back in those days, the Santa Fe terminated at Richmond where there was a ferry. We went on that ferry to San Francisco and from San Francisco to Oakland on another ferry. My Uncle Horace was along with us.

We finally settled in a little house up above Trestle Glen; we were past Lake Merritt, past the F. M. Smith Estate, near the end of the streetcar track at Trestle Glen. Right near there we rented a house. Andrew, Thurlow, and Henry soon found jobs and we settled in to live there. But later on we moved.

Dickman: What are some of your memories of the Trestle Glen house?

Crafts: One incident I remember was while we were in that place. One spring or early summer morning, we kids were down in Trestle Glen, and one boy brought along some matches. And so he started setting little fires and we set one after another until finally we got one that was too big for us and we high-tailed it up to the end of the streetcar line at Trestle Glen and saw the fire trucks all going by. I can remember also that evening my father asking me if we knew anything about that fire and the only time in my life I ever lied to him, I told him, "No, we didn't know a thing about it." I regretted that lie many times after that.

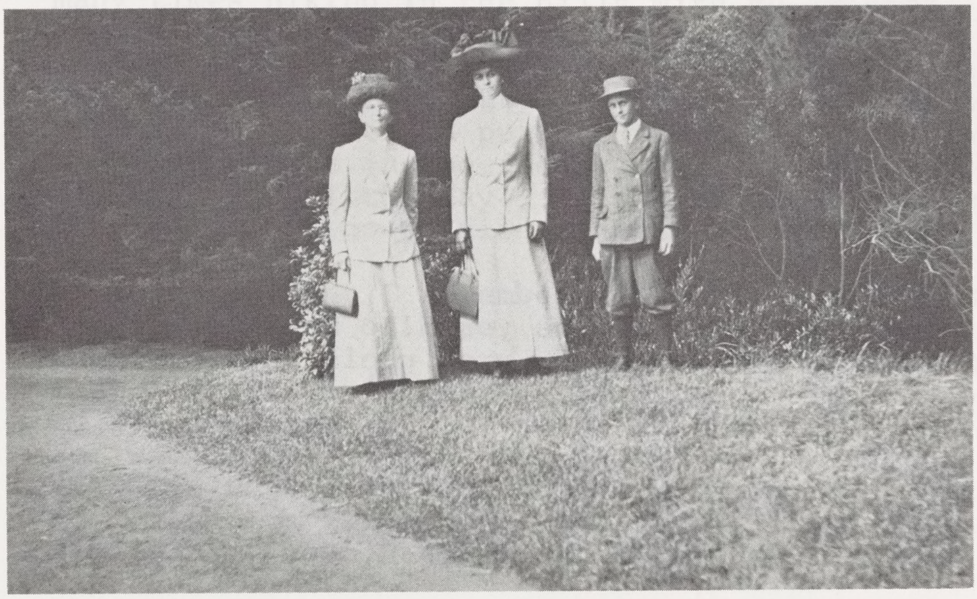
I had my first year of school in the Thirteenth Avenue Grammar School, which was out in East Oakland. And then during the next spring, my brothers and father went out and found a new house farther out which we were able to buy. It was in what is known as Laurel Grove. And it was near the Allendale School and the Allendale carline. It was pretty well out in the wilds because I can remember going up into the foothills half a mile or so away and picking blackberries, bringing them home, and my mother making a pie. And then later we used to go up to Redwood Peak and pick huckleberries. And my mother could make huckleberry pies from those. It was right near the place where Joaquin Miller had his home.

I early learned some of the arts of agriculture. We grew vegetables in our garden. And we had Himalaya blackberries in our yard, and I got experience pulling weeds in the garden, digging dandelions out of the lawn and handling these blackberries. So I had early experience with preparing the soil and sowing seeds and killing weeds.

My schooling resumed in 1904 at the Allendale School and I went on for several years in that school. I remember very distinctly the 1906 Earthquake and the fire in San Francisco. My dad would take us up in the hills, and we would watch the flames of the fire in San Francisco. After it was all over, he took us over and we wandered around in the ruins of the earthquake and fire in San Francisco. We brought home melted glass bottles and burned marbles.

Dickman: Who were some of your friends then?

Crafts: Two boys I remember were Charlie Corey and Ishmael Grimes in my school class. Another boy that we knew quite well was Skinny Hoppe. He lived in one of these houses with the lower floor as a basement and they lived up above on



Golden Gate Park, San Francisco, circa 1909,
with Mother, sister Mary and Alden

the upper floor. And that whole lower basement was open and we set up a screen and some chairs and proceeded to put on amateur theatrical productions. (Laughs) Skinny was the manager of all this and the director. I also remember going by one morning yelling out, "Skinny," and the window opened and his mother leaned out and said: "His name is not Skinny, his name is Adolph." (Laughs) But we continued to call him Skinny. I always wondered about her, but I realize now that she was an alcoholic.

So, I lived out in the outskirts of Oakland. I remember many times hiking in the hills with my friends. One time we saw a fire and ran over to see it, and there was a sheriff and his deputies there working on the fire. They pressed us kids into duty. Gave us green branches and told us to go out and put out the fire in all those piles of horse manure in the field. And we had to work at it all the rest of the day. It was pretty hard work so after that we didn't go to fires in the hills.

Another incident I remember very well was when George Metge, a friend of mine, and I got a job picking cherries and this went along very well. Then one day I decided that I'd like to have some of those cherries, so I filled my lunch bucket and for some unknown reason the fellow for whom we were working asked to see my bucket when we finished that evening. And he weighed it up and charged me for the cherries that we'd taken. So I learned a little bit about business in those days.

I went to the Allendale School for the grades two, three, and four. And then in the fifth grade I went to the Upper Fruitvale School. In this case, I think that the Upper Fruitvale School needed students. The district in which it was located was getting old and there weren't enough students, so they moved us from Allendale to Upper Fruitvale. In this class was a boy, Jack Scammel, and he and I were very good friends. One day he convinced me that I should go along with him and perform in a minstrel show that their local church was putting on. His dad was the end man and I can remember the many times that I went and practiced for this show. When it came off, they covered our faces with black cork, and we were a bunch of small black boys.

And when I was about in the fifth or sixth grade, I became rather restless; the school wasn't keeping me challenged. They used to send me down to the first grade. And then the teachers got together and they advanced me a grade. And from that time on I had no further difficulty.

II. HIGH SCHOOL AND FIRST YEAR COLLEGE

Dickman: Where did you attend high school?

Crafts: The principal of our high school was Pop Rossiter. It was the J.C. Fremont High School down on Foothill Boulevard. The incident I remember most was the fact that this was the time when ragtime music was popular, and somebody had introduced the one-step dance. Well, Pop Rossiter gave us a big talk about dancing, proper dancing, and declared that the one-step was outlawed in his school. Well, they had a day each year when the better students in the class were given the opportunity to administer the whole school. They were sent in as the principal and assistant principal and so forth. And on that day, this group of young people went in on the stage, let the screen down and danced the one-step; engaged in sin. (Laughs) We had a long preachment about that from Pop Rossiter and I think some of those kids were even let out of school.

In high school I had two teachers that I remember; Brasefield, who was a math teacher, and Richardi, who was a history teacher. Both of these teachers influenced my life because they convinced me that an education was required for success in life.

Now, during this time, I remember we boys would take our bicycles, roll up blankets, tie them on the back and ride down Foothill Boulevard to Niles. And go up Niles Canyon and camp overnight. The Essanay Movie Company was situated in Niles at that time and they were making movies. Bronco Billy Anderson and some of his cohorts were the actors. They would come driving up the canyon in an old buckboard and would get out and set up the camera and they would go through the process of making movies right there in the canyon. I can remember one time when the heroine, who was a very beautiful young lady, was walking across a stream on a board, and the thing slipped and she fell in the water. They immediately packed up and went back home. This just happened to be on holiday in the spring and they were due to be in San Francisco and so they just quit making movies at that time.

My high school started in January, 1912. During the time I was in high school, the Panama Pacific International Exposition was going on in San Francisco. Before that exposition, they had road races in Oakland where the automobiles would race on Fourteenth Street from Fruitvale to Hayward, then back along Foothill Boulevard and around and around. I used to see those races. The first one after they set up the Exposition on the grounds in San Francisco was run right on the Exposition grounds.

Crafts: The whole place was blue with castor oil smoke from those racing engines.

The Panama Pacific Exposition was a great show. I took a model airplane over and put it on exhibition as a part of the exhibit from the Oakland schools. Lincoln Beachey was the stunt flyer at that time, and he found out that the Germans had designed a plane which they called the Albatross, which was a very efficient airplane. Beachey thought he had to have one of those. So he sent over and had one sent to him. He got in that plane and went up to about 5,000 feet and then started one of his famous nosedives that he used to do customarily in his Curtis plane. When he got down about half way, the wings flew off and the fuselage went in the Bay and Lincoln Beachey lost his life. They had Art Smith come in and he did the loops and the barrel rolls and all the fancy flying. He was more cautious and he survived till the end of the Exposition.

During this time my brother Andrew, who was a red-blooded young American, got mixed up with some people around the neighborhood. There was a woman they called "the merry widow," and he was seen in her company and so our dad gave us a big lecture on morals and induced Andrew to take the advice of Uncle Albert and go to Wyoming. He went to Wyoming and in a short time Thurlow followed him and the two of them bought a sheep wagon and went out and took up homesteads and lived out in the prairies.

Now in 1915, my brothers leased a ranch down in Plainsburg, south of Merced. It was an alfalfa ranch, about forty acres of irrigated land. I went down in the summer vacation to work.

Dickman: Which brothers were on the ranch?

Crafts: Henry and Thurlow were the two brothers who were in this deal at that time. Andrew came on later and worked with them too. Thurlow and Andrew had come back from Wyoming. Just got discouraged I guess. Life in a sheep wagon was dull, so they came back home to California.

The ride down from Oakland to Plainsburg by bicycle was about a hundred and sixty miles and I made it clear to Merced the first day. A lot of that by hanging on to the back end of a Model-T Ford car. In those days if you really rode pretty fast on a bike, you could catch a Model-T and the drivers wouldn't object. I remember going out over Altamonte Pass behind a Ford, (laughs) and I made a hundred and sixty miles a day, which is pretty good for a high school kid. Thurlow expected me the middle of the next day. Instead, I arrived there for breakfast in the morning.

Alden S. Crafts
high school graduation
1916

Crafts: It was an irrigated alfalfa farm, and I learned how to clean ditches with a shovel. We had one with galvanized pipe as a handle, so it was heavy and you could cut with it. And I can remember the gophers coming out of their holes when the water came by. I learned how to let the water down into the big long central concrete pipe. You had to let the water in slowly. If you let the water in too fast it would rush down and air would become compressed and pretty soon water would come burping out of all the standpipes. So I learned about that and also to let water into the checks at the right rate, and to stop it before it got too far because if it went down and flooded the end of the check, the alfalfa would drown out.

I fed hogs. We dipped hogs in a dipping vat to keep the lice off of them.

Saturday nights we used to go over to Planada to dances, Dorothy, Thurlow and I. We really enjoyed this very much and one time Thurlow wasn't going to be able to go. So, I went out and got the horse tied up in the barn. I had never harnessed a horse and as I was standing there holding the horse collar trying to figure out how it fit on the horse, Bert Waller, a neighbor, came in and he showed me how to do it. But I never did get over the reputation of the city boy who didn't know how to harness a horse.

We would go to the dances and stay until midnight and have a dinner and then come on home. Now this year since I was out of order, because I had lost one-half of a year in grade school, and since I had started high school at Christmastime, I wanted to get back onto the regular schedule. So I just stayed this fall until Christmastime on the ranch and got a lot of experience. I had a canoe that I'd made with barrel hoops and canvas and it was a rather touchy thing. You had to balance it constantly; if you forgot to balance it, it'd go over on you. And I had a shotgun and I used to go down in the fields and shoot cottontail rabbits and those we cooked for dinner.

Then I started at the University of California in the Autumn of 1916. I lived with my older sister Mary, who at that time owned a home out on the edge of town between Berkeley and Oakland, within walking distance from the University.

Dickman: What made you decide to go to college?

Crafts: I grew up with the idea of going to college because my mother insisted that I was to go to college.

Dickman: Had your brothers and sisters gone?

Crafts: No. Andrew was thinking of going at the time the Panic of 1897 hit my dad and he had to go out to work and from then on the rest of the kids all worked. When we got to California, they all got jobs and worked. And that's the only way we kept this family going. My mother kept the family together really. She did the cooking and ran the household and they would all turn their salary checks in to her and she'd give them back money as they needed it.

Dickman: So you were the first one that could afford to go?

Crafts: I was the first one that could afford to go, that was it, and she was determined that I go. I never questioned it; never thought otherwise than that I was going on to college.

When I started college, I worked in my spare time. First I worked in a grocery store. I couldn't remember the names and the prices of all those items and decided clerking in a store wasn't for me. During Christmastime I went down to Oakland and got a job in the Southern Pacific roundhouse. I was wiper and extra caller. Everytime an engine would come in from a run, I'd take the polish and go out and polish all the brass on the engine. I'd take a black concoction and put it on the firebox and the wheels and doll up the engine for its next run. And then as extra caller, I would take a bicycle and go out and arouse the crew and tell them when they were due to leave on a train.

Now, I went to Berkeley and took botany from Professor Gardner. I took chemistry from Joel Hildebrand. I took German, mechanical drawing, pathology, music, hygiene, and physical education. I took ROTC and I can remember the ROTC very well because as the last exercise we had in the fall, they had staff sergeants come over from the Presidio in San Francisco and they got us outside and going through the exercises. We put the bayonets on the guns and we were told to "jab the sons of bitches in the eye." (laughter) That was how we were to use our ROTC training. And I decided that it wasn't very educating.

Dickman: What was Gardner's full name?

Crafts: I don't know.

Now after I had been to college one year, I had been thirteen years in school without stop and I was just tired of school and decided I was going out. I wanted to get some farm experience. My mother too had convinced me that I should go into agriculture, that the modern agriculture was getting interesting. So I stopped out. I found that the University owned the Kearney Ranch down near Fresno at that time. Parker Frisselle was the manager and I corresponded with him and he took me on. I explained that I had worked on this other farm in Plainsburg and he gave me a job as a regular farm hand.

I cared for hogs; I hoed Johnson grass; I pitched hay. I can remember one incident. We were out piling barley hay in July and I was on the stack. They were pitching it up to me and it was getting hotter all the time. Along about the middle of the afternoon, I found myself soaking wet, my clothes were wet and even my shoes were wet. Somebody went and looked around at a thermometer they'd hung on the shady side of the stacker and it was a hundred and ten in the shade. We all quit and went in and took showers. We decided that it was too hot for us to work.

We had an old straw boss there who drove around in a two-wheel cart with a mule. I can remember him very well. He'd go around from job to job and tell us what to do. And then on Saturdays, he'd take off for Fresno and he'd stay drunk and if we were going to work on Monday, he was able to get up and going. But if we had an extra day on the holiday, then he would just stay in bed and drink whiskey for an extra day. That was his whole pleasure in life, I guess, was whiskey.

When fall came, and the work became a little slack, I decided I'd make a change again. I took the bus up to Davis and enrolled in the ten-day tractor short course. And after that I got a job out in the Sutter Basin.

Dickman: Who taught the course?

Crafts: I don't know who taught it. Fletcher was the head of the Department at that time.

But after the ten days I got this job out in the Sutter Basin. The Phil Armour Company was plowing up tules. They had big old Best tractors. I wasn't educated enough to drive a tractor, so I swamped plows behind this big old tractor. I can remember that after work we slept in a galvanized iron barn. After a few days my clothes began to get dirty, so I washed the clothes and I hung them out on the barbed-wire fence to dry. The air had a smell I can remember having noted recently when it was foggy and cold. And those clothes; I'd come home and wring them out and I'd go out the next morning and wring them out again. So finally I hung them up on the tools inside the barn and got them dry enough to wear, but it wasn't very pleasant.

I learned another thing about working for industry. We would take out a whole big box full of groceries for our midnight meal. I was working nights, and we'd eat what we could and the rest we'd just throw out on the ground and plow under. And I said, "What's the idea of this; isn't this a waste." "Oh," they said, "Uncle Phil will pay the bill." (Laughter) That was Phil Armour. Uncle Phil did pay the bill.

Crafts: I learned also why they call Swedes "squareheads." We were out seeding after we got the plowing done. We went out and seeded in barley in the Sutter Bypass. Finally, this old Swede's seeder ran out of barley; they didn't have anymore. So he took a shovel and he filled the hopper with soil. He couldn't stand going over the ground without putting something in that machine of his. (Laughs) As if that would do him any good.

III. MORE FARMING EXPERIENCE

Crafts: Well, about this time the lease on the farm down in Merced ran out. And I went on up to Oakland. Andrew had come down to the farm in Merced from Wyoming, and Henry and Andy and I took Henry's old Model-T Ford and we started out looking for a farm. We went up through the Napa Valley to St. Helena, Santa Rosa, Healdsburg, Cloverdale, to Ukiah, and there we heard about Potter Valley which was about seventeen miles out of Ukiah on the Russian River. We drove up to Potter Valley, stayed in a little rooming house there overnight, and spent the day looking around and finally found ourselves a place which we thought would be suitable. It had about forty acres of bottom land and sixty acres of hill pasture; we bought this farm. We paid five thousand dollars down and signed a mortgage for eight thousand dollars with interest at seven percent from the Ukiah Bank. Later I was able to get a farm loan on this farm which only cost five-and-a-half percent.

We milked cows, we separated cream which was sent to the Golden State Creamery in San Francisco and the butter fat in those days was running between fifty and seventy-five cents a pound. So you see that the farmer has shared with a lot of other people in this inflation.

This was 1918, during the war; and the government was paying two dollars and twenty cents a bushel for wheat to encourage growing wheat for the war. We got there in the early Spring and got established on our farm. And we threshed after we'd been there. We took our team and wagon, and Henry and I got jobs on this threshing crew and went out and threshed. We would throw the bundles on the wagon and haul them to the machine and throw them on the draper. And it was a big thresher. It had a thirty-six-inch cylinder. It was run by a big old steam tractor. And we threshed on every farm in Potter Valley that year.

One experience I'll never forget. We had a water boy who would take the water barrel out and fill it at the various farms. One day we noticed that as we drank the water, we had a lot of fur in our teeth. (Laughs) The water was from an old abandoned well out in the field, and we thought that a rabbit had gotten into that well. The next day we had a different water boy. (Laughter)

There was a cook wagon and we ate our meals and slept in the straw stack. We only went home on weekends. As soon as we were through with the threshing season, Henry went over to town and found a shop where he set out an auto

Crafts: repair sign and started in repairing automobiles. But it wasn't very profitable, so he finally went back to Oakland, where he'd get a good job.

I was on that farm for seven years. During that time, Andy and I built a barn and a silo. It was a project of the Farm Bureau at that time, to build these wooden silos and they had a plan where they laid out a floor and made a circle of thin redwood boards, bending them around in a circle and then we would fit our circles inside that and nail them together and then pry them out. It took a whole series of these circles, one every two feet on the silo. We built a thirty foot silo, ten feet in diameter.

We went up into the hills and cut out fir poles which we peeled and brought down and used for the rafters and main frame of the barn. This iron-roofed barn I remember very well, mowing hay back in it in the middle of the summer, because it was terrifically hot.

I had another experience in those years. I read in the Pacific Rural Press that George P. Gray with the State Department of Agriculture had been trying to kill wild morning glory in sugar beets and he had found that if he sprayed with a dilute solution of sodium arsenite that those roots would be killed down two or three feet in the soil. When I read about this, I went and got some arsenic and tried it out, and sure enough in some way or other, the arsenic was going down into those roots and that fascinated me. And later on of course I worked more on that.

We bought the first Fordson tractor in the Valley. And I did a lot of custom plowing, leveling and discing. We also raised turkeys on our farm. I can remember those turkeys; we had twenty-five or thirty of them. They would wander up in the fall of the year to the top of the hill behind the barn and get filled up on acorns and then take off and all come flying down into the corral. We killed and picked these turkeys and shipped them to San Francisco. And in those days we got about seventy cents a pound for them. And that was in 1918, 1919, and 1920.

I was scheduled in 1918 to go to Kelly Field, Texas, and go into the air force. I had agricultural exemptions up to that time, but I guess it was getting along toward the end of the war and my exemption ran out and I was to go to Kelly Field about the fifteenth of November, 1918. And the eleventh of November they had the Armistice. So I missed going to war.

Crafts: On the second year we were in the Valley, we were threshing on Charlie Hardisty's farm. He was a neighbor, his back fence and our back fence was a common fence. So we were on the east side of the Valley, he was down in the center of the Valley. We were hauling bundles on Hardisty's farm into the threshing machine when we saw Charlie's wife and his youngsters out there. And one of those was a new girl whom I had not seen before. She had red hair and was a nice looking girl. I was, of course, a young fellow and interested. I found out later that she'd been going to high school in Ukiah and was just there for the summer but she would be going to the new Potter Valley High School which was building then in the Valley. She started that fall. It turned out that her name was Alice and later I joined the Grange and she led me around through all the various stations. And so, we became acquainted.

There was a Mr. Johnson in the Valley, who ran a stage line from Potter Valley to Ukiah every day. He took cream and various things in and brought people back and forth. He was a musician and loved to play. He played the horn and he had a piano. He would set up the piano and get some of the neighbors to come and they would play music on Sundays. And one Sunday, I went and Alice was playing the piano and he was tooting on his horn and when they finished, Alice asked me if I'd like to go home and see her new baby sister. (Laughs) She had just been born. And I, of course, was (laughs) very interested in seeing baby sister. So, I walked her home over three or four barbed wire fences and so forth and saw her baby sister, and from then on, I dated and took her and her sisters to dances.

I can remember one other episode that was rather interesting. One Sunday evening when I was walking down through my corn field to go over and take Alice to church, there was a skunk walking up the next row of corn, going to see his girl. And we met out in the middle of that corn field and whoof!! Well, I was choked and went over and gave a lame excuse through the Hardisty's back door and then I went on home. And I was wearing the only suit of clothes that I had. My mother and I worked on that suit of clothes. She steam pressed them; she used ammonia; we finally took them out and buried them for awhile and then we took them back and steam pressed some more. Finally, I got to the place where I was able to wear them out in polite company. But if I went to a dance, about the second or third dance, people would get to looking around. (Laughter) That was quite an experience and I decided that if I were going to have an environment, I didn't want any skunks in it. (Laughs)

Crafts: In 1922, my older sister, Mary, took me to the livestock show at the Cow Palace in San Francisco. And there I met Jim Thorpe, who had a bunch of Duroc hogs and Jersey cows. I made a date with Jim to go with him on the fair circuit. And so that next summer, I got on the bus and ran over to Sacramento and joined Jim and his outfit and we went to six fairs; the Sacramento fair, the Stockton fair, Fresno fair, Hanford fair (I think), and then down to Los Angeles and Riverside. We took in six fairs and I learned all the ropes on polishing the hoofs and braiding the tails and brushing the cows and feeding and so forth.

I remember when we were going over the hump from Bakersfield to Los Angeles, the Tehachapi Pass, we went through a tunnel. We were in a stock car with a floor above and the animals below, and the old bull was right down below us. He didn't like the smoke and stuff going through the tunnel; I thought he was going to tear the train to pieces. But we finally got through.

I had been dating Alice Hardisty and she went off to Arcata in 1923 to teachers' college, and she came home at Christmastime. After she'd been there a couple of years, she got acquainted with a new fellow from the Arcata bottom, and she stopped writing me and finally got engaged to this young fellow. But later she broke that engagement. She came back, and she was teaching.

First she taught at Branscomb, which is up above Willits; she taught up there on an emergency basis. A teacher had become ill, and instead of staying for her graduation, Alice went down and was teaching at the time of her graduation. But, of course, she graduated. And then she got a job in Willits and lived with her grandfather and grandmother. Her grandfather was the town sheriff at that time.

This fellow she'd been engaged to was Eph Turner and she had rather an interesting experience. She went to a religious meeting in Willits where a revival speaker was really laying it on hard. He asked those people if God was having His way in their lives. On her way home that night, she said, "No, he isn't." So she went home and wrote Eph a letter and sent his ring back to him and broke the engagement. Now a few weeks after that in Potter Valley, I decided one night I'd go to church. I hadn't been to church for a long time. Alice and I went quite frequently, but I hadn't gone for a long time since she'd quit me. I went to the church and I went in and Alice was sitting there playing the piano. I looked down at her and she looked back at me and smiled, and we walked home together. As I entered the living room she had kind of a grin on her face and her dad looked nonplussed because he'd just gotten through telling her that she couldn't expect to go with me anymore because I had been seen in Ukiah going with another girl. (Laughs) Well, we walked home together after that church and saw each other a lot.

Crafts: Now, we had an interesting situation. Professor Richard Holman, who was of the team of Holman and Robbins, a botanist who wrote the famous textbook, had married a Potter Valley girl and so they came up on weekends from Berkeley. Holman and his family came up for the summer vacation. Holman liked cream and we had Jersey cows and were separating the milk and he used to come over to the farm and buy cream from us. One day he asked me, "How is it that you are on this farm? There's not much of a prospect in Potter Valley for a young man on a farm." I said, "No, I've had a year in the College of Agriculture, but I wanted to get farm experience." Well, he said, "This is no place for you, you'd better go back and finish up your schooling." Well, at this time, Alice and I were getting rather serious, so I decided that he was right because that little old farm of ours would never support two families. And so Holman persuaded me to go back to college and he gave me a letter to Dr. Robbins.

So then for the preparation for my career, I returned to Davis in 1925. I took my letter to Dr. Robbins and he gave me a job washing dishes in the laboratory. My mother and Alice were very happy about this, but Andrew wasn't because it was going to leave him alone on the farm. But I decided that if Alice and I were going to go seriously, I'd better become engaged. So we were engaged before I left for the school at Davis.

Alden and Alice Crafts
August, 1926

IV. RETURN TO COLLEGE - DAVIS AND BERKELEY

Crafts: Well, with Holman's letter to Robbins, I had a job washing dishes in the lab, pulling weeds in the sugar beet plots, and collecting male asparagus flowers from male asparagus plants. They're dioecious you know, and they were filled with gnats. That was quite a job. So I learned a little bit more about farming.

Dickman: What classes did you take then?

Crafts: I took Plant Anatomy and Plant Physiology from Dr. Robbins; Quantitative Analysis and Organic Chemistry from Bisson and Sewell; Animal Husbandry 7 from Elmer Hughes; English from Susan Cobb (who later became Susan Regan); and for physical education, I took tumbling from Heinie Severe. I learned histology from Dr. Robbins and was able to make slides which we used in our classes.

Picnic Day was the big day on the campus, of course, and in 1926, Alice came over with some friends from Willits and we set our wedding day that evening. We were going to get married on my birthday.

I had planned to go and prepare for Smith Hughes teaching or extension work. Robbins convinced me I should go to Berkeley and continue in research and work toward a research career. Alice had applied for a school in Davis and she obtained the position, but she had to give it up because we were going to Berkeley.

We were married on June 25, 1926, in the Potter Valley Methodist Church where she had gone to church all of her life. We went to Santa Rosa and then on to San Francisco and took the ferry over to Oakland. Then we went out to Berkeley.

Alice got a job teaching in the Margaret Bentley School. A member of her family, I think a cousin, was teaching there and gave her the introduction and she got a position.

Through Tom Tavernetti, who was an Assistant Dean of the College of Agriculture, and who knew of my interest in weed control, I got a job with Dr. P. B. Kennedy in the Agronomy Department. The job, the final objective of this particular work, was to discover the mechanism of action of the acid arsenical herbicide. The money had been given to Kennedy by the KMG Company. KMG means "kills morning glory." A small outfit in Berkeley produced this acid arsenical spray, which was the only thing we had in those days to work on perennial weeds.

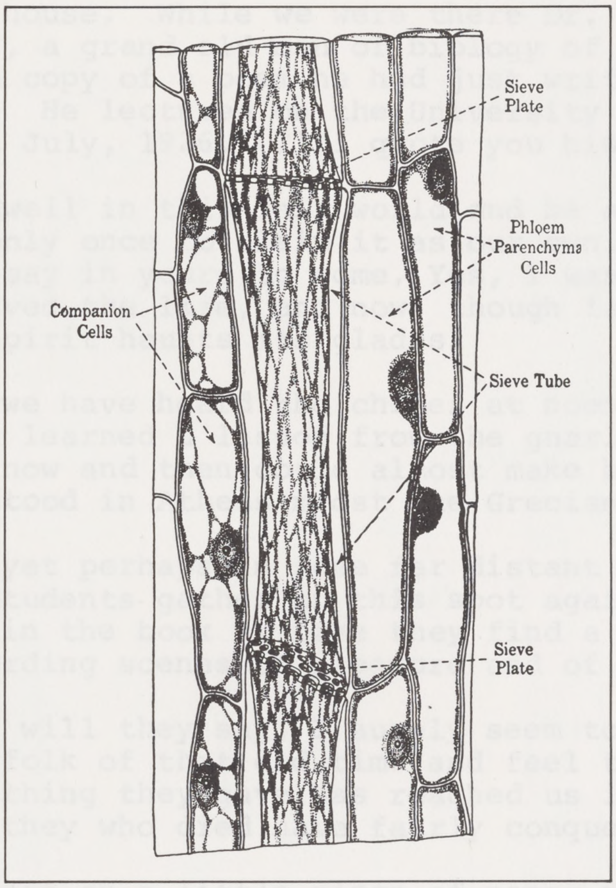


Illustration by A.S. Crafts
in a textbbok on botany
by W.W. Robbins and E. Weier

Crafts: We found an apartment within walking distance of our work. We went back to San Francisco, took the Delta Queen to Sacramento and rented a small house in Davis on "D" Street from Jane Vansell. We settled in and I worked for Dr. Robbins. We collected herbarium specimens in the Capitol Park. For two weeks we lived in Dr. Robbins' home on Russell Boulevard which is now the CACA house. While we were there Dr. T. D. A. Cockerell, a grand old man of biology of those days, gave us a copy of a poem he had just written in Berkeley. He lectured on the University of California campus in July, 1926. I'll quote you his poem.

To dwell in this fair world and be a part of it,
If only once to claim it as our own,
And say in years to come, Yes, I was there,
I lived the life, and now, though far away,
My spirit haunts its glades.

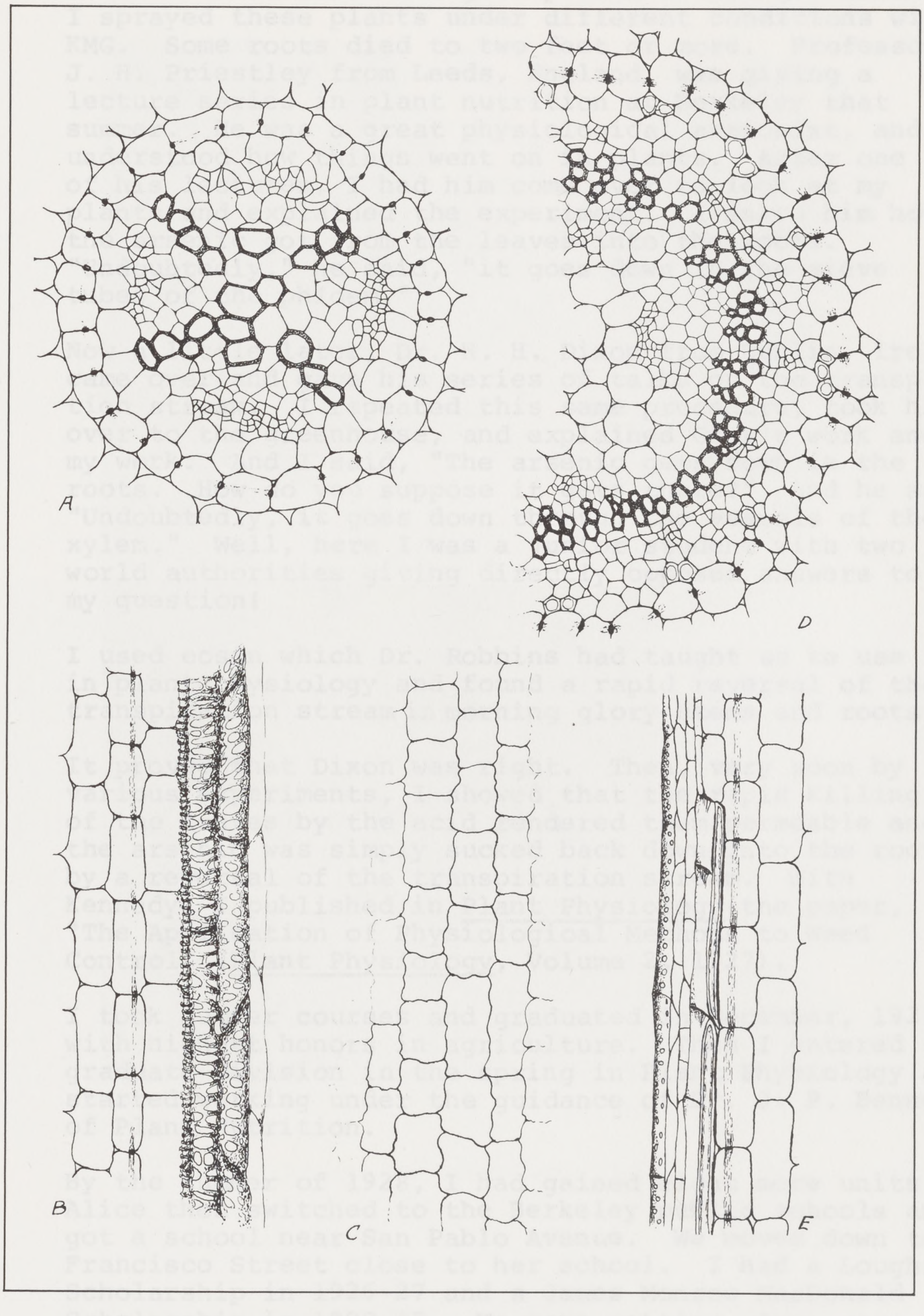
For we have heard the chimes at noon and eve,
Have learned a lesson from the gnarled oak,
And now and then could almost make believe,
We stood in Athens midst the Grecian folk.

And yet perhaps in some far distant age,
As students gather on this spot again,
And in the book of time they find a page,
Recording scenes of pleasure and of pain.

Then will they say, I surely seem to know,
The folk of that old time and feel their breath,
Something they gave has reached us in its flow,
And they who died have fairly conquered death.

We have that on a little piece of paper in his handwriting in our memorial book that we made at Berkeley.

We went to Berkeley in August, 1926. I registered in the University and took Biochemistry from Professor Hoagland, Soils from Burd, Entomology from Stan Freeborn, and Genetics from Babcock. I started work for Kennedy. I sprayed morning glory plants in Babcock's *Crepis* garden north of the agricultural hall. I sprayed them with KMG, and observed the effects on the tops and on the roots. The tops were soon killed and I took samples of the roots at various intervals thereafter and I found that some of them were apparently dead because they became moldy quite soon. Others stayed bright and white. When I analyzed these, I found that where they were brown or showed signs of injury they contained arsenic. So this proved that the arsenic was moving from the leaves down into the roots.



Drawings of A.S. Crafts and Dr. P.B. Kennedy
"Anatomy of Convolvulus"

Crafts: In the Spring of 1927 I dug roots at Davis in a trench out in the agronomy field. I planted these roots in soil tubes and grew plants in the greenhouse. I sprayed these plants under different conditions with KMG. Some roots died to two feet or more. Professor J. H. Priestley from Leeds, England, was giving a lecture series in plant nutrition at Berkeley that summer. He was a great physiological anatomist, and understood how things went on in plants. After one of his lectures, I had him come over to look at my plants and explained the experiment. I asked him how the arsenic got from the leaves into the roots. "Undoubtedly," he said, "it goes down in the sieve tubes of the phloem."

Now a little later, Dr. H. H. Dixon from Dublin, Ireland, came over and gave his series of talks on the transpiration stream. I repeated this same procedure, took him over to the greenhouse, and explained Gray's work and my work. And I said, "The arsenic gets down in the roots. How do you suppose it gets there?" And he said, "Undoubtedly, it goes down through the vessels of the xylem." Well, here I was a junior student with two world authorities giving directly opposed answers to my question!

I used eosin which Dr. Robbins had taught us to use in plant physiology and found a rapid reversal of the transpiration stream in morning glory stems and roots.

It proved that Dixon was right. Then, very soon by various experiments, I showed that the rapid killing of the leaves by the acid rendered them permeable and the arsenic was simply sucked back down into the roots, by a reversal of the transpiration stream. With Kennedy, I published in Plant Physiology the paper, "The Application of Physiological Methods to Weed Control" (Plant Physiology, Volume 2, 1927).

I took summer courses and graduated in December, 1927, with highest honors in agriculture. Then I entered the graduate division in the spring in Plant Physiology and started working under the guidance of Dr. J. P. Bennett of Plant Nutrition.

By the summer of 1928, I had gained eight more units and Alice then switched to the Berkeley public schools and got a school near San Pablo Avenue. We moved down to Francisco Street close to her school. I had a Loughridge Scholarship in 1926-27 and a James Monroe MacDonald Scholarship in 1927-28. We were getting along very well and we bought ourselves a used Chevrolet automobile.

Alden in Berkeley, 1927

Crafts: I worked during that year for Harold Offord of the U.S. Forest Service on the white pine blister rust problem. The problem was to get rid of *Ribes* species, that is, wild currents and wild gooseberries. Sodium chlorate was mainly used but it was very hazardous because after the material dried, if anything brushed past those sprayed plants, they'd catch fire just like a match. So, in the Summer of 1928, I went by train to Moscow, Idaho, and then out by bus to St. Mary's and spent the summer working in the woods there, living in a little old inn by the side of the St. Mary's River. Early in the summer, Alice and Dr. Bennett drove up and then we had the summer together out in the woods.

We returned and I continued research in the fall. I selected the problem, "Movement of Assimilates in Plants." This was a problem which was highly controversial in the field of plant physiology at that time. Theodor Hartig in 1837 named the sieve tubes and saw exudation and visualized a mass flow in the phloem. DeVries in 1885 proposed that protoplasmic streaming was responsible for the movement of materials in the phloem. And Strasburger in 1891, in a rather thorough review, proposed that the sieve plates of angiosperms were open and so would accomodate mass flow but in gymnosperms they were possibly closed. So it still left a problem. Czapek proposed that all organic nutrients moved through the phloem. Haberlandt and Sachs, two plant physiologists at that time, proposed that only nitrogenous materials moved in the phloem. And Ernest Willy Schmidt proposed that the phloem was not specialized for transporting in any way and so it left us with almost a complete blank as far as the mechanism was concerned. And at that time, Dixon in Dublin proposed that all nutrients moved through the xylem and Curtis of Cornell that all assimilates moved through the phloem. He had done a lot of ringing experiments and thought that he had proved that everything moved in the phloem.

So this was the state-of-the-art when I started work in 1928. I used squash plants in the Botanical Garden. I cut off the tips of stems, collected exudate, weighed and dried it, and reweighed it to determine the dry-weight composition. I sectioned the stem, projected and measured the cross-section areas and calculated the velocity. I proved that at the initial period of cutting, for the first few seconds, the phloem contents moved out at a velocity of a thousand centimeters an hour.

Mason and Maskell in Trinidad, working on cotton, did some very critical work and showed that the movement of food materials, or assimilates, in plants followed a source-to-sink pattern; that is, from where the assimilates were synthesized to the place where they were utilized.

Crafts: I worked out the system of differential osmosis to explain flow along a pressure gradient developed osmotically, only to find that Münch had found this same mechanism and Bennett found that he had published a book on it; so we bought the book and I translated it from German to English.

I obtained a National Research Council postdoctoral fellowship to work with Dr. O. F. Curtis at Cornell University on this problem of the mechanism of assimilate movement. At the time of my final examination, Dr. Robbins, who was on my final committee, stepped up and asked me if I would accept a research position on weed control in his department. I explained that I had this National Research Council fellowship and would like to go to Cornell and work for a year. So he said he would hold the position over for me from 1930 to 1931.

Dickman: Tell me something of your life with Alice during this time.

Crafts: Alice and I had a very happy life in Berkeley from 1926 to 1930. We got very well acquainted with Dot and Forrest Crawford. Forrest had a problem which he explained to Alice one day when we were out on a botany field trip. He had a red-headed girl in Egypt and he was hoping that he could marry her. He was going to try to bring her to Berkeley, but he had no place to take her. So we said, "Come and live with us until you can find an apartment." So this worked out very well. Alice was rather worried about the situation because Dot was the daughter of the head of the Bank of England in Cairo and had gone to some of the best American finishing schools. Alice had just come from Potter Valley, a little place up in the country. But when they came on the train, Dot jumped down off the train and came toward Alice, and Alice went toward her and they shook hands and they had a friendship that lasted for many years even after we left the campus.

We went to rallies and initiations. I was initiated into Phi Sigma, Alpha Zeta, Sigma Xi, and Phi Beta Kappa. In fact, it kind of strained our finances for awhile paying the fees to get into these societies. (Laughs)

We went to dances in the Hillside Club, where we met the Essigs and the Wellmans, the Cruesses and many others. On August 25, 1929, from the Crawfords' apartment on the hills above Berkeley, we watched the Graf Zeppelin come in over the Golden Gate.

V. CORNELL RESEARCH

Crafts: In June, 1930, we took off to work with Professor O. F. Curtis at Cornell University. He was spending the summer in Columbus, Ohio, teaching summer school. We drove our Chevy through Nevada, Utah, Grand Lake, Colorado, Fall River Pass, Big Thompson, and Fort Collins, where we visited with old friends of the Crafts family. Then we drove to Manhattan, Kansas, where we had a visit with Professor Zahnley, who was working on sodium chlorate on bindweed. He had a paper on this subject. Then we went on to Columbus.

The first problem I had was the fact that we were in the Biology Building and there were researchers in that building raising flies and counting them and doing some sort of experimentation. But when they got through, they just turned them loose. The flies all seemed to come and congregate in my room during the night and when I got there in the morning, the first thing I had to do was shoo all the flies out! (Laughter)

I looked up Professor C. J. Willard and examined chlorate plots which he had there on quackgrass and Canada thistle, new perennial weeds to me. I got acquainted with Curtis, Willard, Transeau, Sampson, Camp, and Barney Meyer. I think that Paul Kramer was in Curtis' summer session class there at that time. He later became a very well-known plant physiologist.

While in Columbus, we took a trip to Chicago to visit with Alice's old friend, Ester Roebuck. And on coming back home to Columbus, we had a wire from Potter Valley that Bessie, Alice's younger sister had been killed in an accident on the Cloverdale grade. Well, there wasn't much we could do about that because we didn't have the money to go home, and we did have the loan to go on to Cornell to do my work.

At the end of the summer session we drove to Ithaca and I started work in earnest. The anatomy and plant physiology of cucurbits was the first problem I tackled. I studied again the volume, the composition, and the velocity of exudation. I studied the anatomy and physiology of the potato, and calculated that it would require the velocity of somewhere between fifty and one hundred centimeters an hour of the assimilate stream to account for the volume growth of potato tubers. I thought that the sieve tubes could not be plasmolized. From my experiments, I could not plasmolize them by putting a strong sugar solution under the cover glass. And therefore they were permeable. But later, Esau, Cheadle, and Currier proved that the sieve tubes remained alive and were capable of plasmolysis; my failure to do so resulted from the fact that I had used no particular precautions in cutting the tissues. Dr. Cheadle did the cutting for their experiments under a sugar solution with a very sharp microtome and was able to prove that the sieve tubes remained alive. My finding was an artifact of processing. The sieve tubes remain alive and can be plasmolized if precautions are taken to prevent shock.

Crafts: While we were in Cornell we took the time off to drive up into New England. We explored Cape Cod, Salem, Bunker Hill, Concord, Lexington, and Boston. We enjoyed Enfield Glen, Taughannock Falls, Watkins Glen, and the Finger Lakes region. We got to know many people at Cornell.

Dickman: What were their names?

Crafts: Well, in addition to the Curtis family, we became well acquainted with the MacDaniels, the Eames, the Petries, the Sharps, the Randolphs, and the Muenschers. Walter Muenschers' weed class, I attended a good many times.

Harold, our first son, was born on January 24 in Ithaca Memorial Hospital. We brought him home and he did very well. In April we took him out to see the new two feet of snow which had fallen (laughs) all over the country.

I was taken in as an associate member of Sigma Xi in Berkeley; when I went to Cornell, I was taken in as a full member into the Alpha Chapter of Sigma Xi. That was the first chapter of the society.

I had a remarkable experience then. I was a graduate student with a job! While I was at Cornell, I met Elliot Weier and a good many other graduate students and practically none of them had a position that soon. It was my interest in weed control that was responsible; Dr. Robbins was thoroughly convinced that weeds constituted a major problem for farmers everywhere, and because he had actually engaged in growing sugar beets, he had practical experience in fighting them. He was a firm believer in prevention of weeds by early control by cultural methods.

So, in June we drove back home to California in our new six-cylinder Chevy, and on July 1, 1931, I started work.

VI. ASSISTANT BOTANIST AT DAVIS

Crafts: My job at Davis carried an Experiment station number. I was on an eleven-month contract which paid more than the nine-month academic teaching position, $3,000 per year.

For my first work I outlined a project; these were the items that I was going to study. (1) The maximum effectiveness of the acid arsenical spray. (2) To formulate a cheap and effective acid arsenical spray. (3) The mechanism of sodium chlorate action (because we knew that we could kill by spraying the foliage and we killed the plants by putting it on the soil and washing it in, and we wanted to know the mechanism). Then (4) after the germination of morning glory seeds, when the seedling assumed the perennial habit, so that it would not be killed by cutting off. (5) The selective control of annual weeds in cereals. And finally, (6) the toxicity of herbicides in soils.

I started my work with a simple knapsack sprayer, a hundred pounds of arsenic trioxide, fifty pounds of sodium chlorate, five gallons of sulfuric acid, and a bundle of lathes for stakes. That was my total supply of materials at the start of my research.

I soon found that if I mixed arsenic trioxide, sodium hydroxide and water in a ratio of 4:1:3, that this mixture boiled up as it reacted and that I ended up with a thick syrupy solution of sodium acid arsenite. And this I could dilute down. When I diluted it down to one percent AS_2O_3, and made it up to five percent sulfuric acid, and applied that after dark to minimize evaporation, and supplied water on the foliage after applying it, that we could get bindweed plants killed down to four and five feet in the ground. The volume of application was five hundred gallons per acre, that was a most effective rate. For about fifteen years, this was the best material to use to control perennial weeds until 2,4-D came along.

In order to work at night, I devised a little lamp consisting of two dry cells and a little bulb out of a flash light and I soldered that to the nozzle of my spray rig so I could work at night and see what I was doing.

Concerning the sodium chlorate, the third problem that I was going to work on, the directions on the container and the directions that we obtained from articles, indicated that the work was all aimed at an aerial spray. They gave the concentration, the volume of application, and all those details required to use sodium chlorate

A simple knapsack sprayer

Crafts: effectively. But I found that if I pulled the plants off and applied the same amount of sodium chlorate to the soil, washing it in by the amount of water to take it down to about the depth of two feet, that the roots absorbed the materials and were also killed. So we finally determined that by using a combination of these two we got results. We would spray the plants and when the tops were dead, we would irrigate the plots and this way we got a maximum effectiveness.

Now to find out how long it took seedlings of bindweed to become perennial, we would irrigate up the plants on dry plots and then start as soon as the seedlings were up, hoeing them off at intervals. We found out that if we hoed them off twelve days after emergence, then let them stand, new shoots would be formed and the plant could survive. In other words, it took the plant twelve days to take on the perennial habit.

I learned from this type of work the answer to a problem I had when I was in Berkeley. The Agronomy Department asked me to explain why KMG had failed on some plots that they had sprayed. By taking a shovel and digging the plants out, I showed that all of the bindweed plants on these plots were seedlings that had developed with the crop of barley which they had raised on the land that spring.

In the work on selective sprays on grain, we proved that sodium arsenite was the cheapest and most effective material. It could kill all of the mustard on an acre of barley with about twenty-five cents worth of arsenic, but we didn't report this because the railroads had been experiencing severe losses of livestock along their rights-of-way where they were spraying with sodium arsenite, and we didn't want to recommend the use of such a poisonous material on the farms of California.

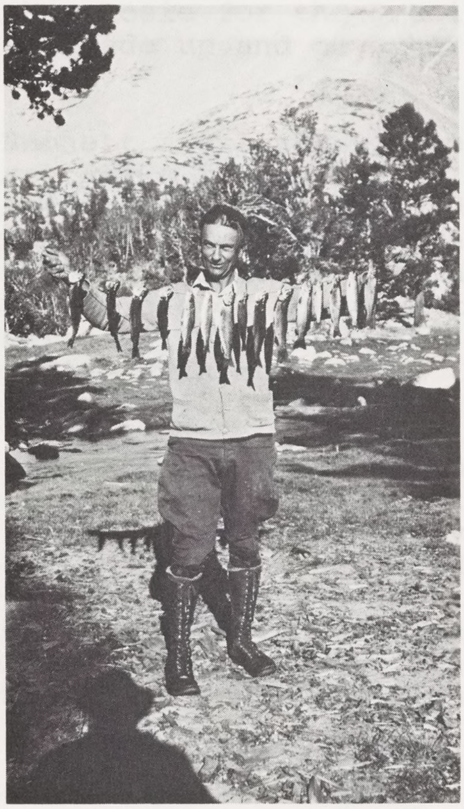
In the winters of 1931 and 1932, I put out plots on soils to study the sterilization of soil by chemicals. Sodium chlorate, sodium arsenite, AS_2O_3 in the dry form were used. I set up pot-culture experiments in the greenhouse using sodium chlorate applied dry and applied as spray to the vegetation and various combinations. If we applied it dry, we always had to put on enough water to carry it down into the soil. And we could control perennials in this way with sodium chlorate. Arsenic trioxide was fixed rather rapidly in the soil, resulting in a very shallow distribution and the sodium arsenite also was fixed. So, we could completely kill annual weeds with shallow roots. Deep-rooted plants would survive. With the use of dry chemicals, arsenic or chlorate, it required sufficient rainfall to carry them into the soil. The pot-culture

Crafts: technique is something that I had learned in my training in plant nutrition in Berkeley. And I ran literally thousands and thousands of these pot-cultures in number two cans with five hundred grams of soil; we watered by weight so that we knew that we weren't overwatering.

Then we developed soil tubes for leaching studies. A celluloid liner surrounded by hardware cloth about the same diameter as a number two can was filled with soil and when we had finished running an experiment, if this soil was wet, we could remove the cover and cut the soil column into nine fractions, put each one of these in a number two can, and find out the location of the chemical in the long tube of soil, which was about three-feet long. This bioassay method has been used in thousands and thousands of studies in universities and industry and even by individuals since this time. The sizes and shapes of the containers have changed, but the principle is the same. You let the plant tell you what the chemical is doing.

Our salaries were cut during the Depression, but later the deductions were repaid. Dick Raynor from Riverside worked for me as a graduate student, coming on in 1932. We put out plots and grew and treated pot cultures in the greenhouse. He started in the Fall of 1932 and the first published results of this work are in *Hilgardia* of October, 1935. The cultures had been cropped five different times; that is, we would grow the plants out for thirty days, cut them off, dry out the cultures, pulverize the soil, put the tops back underneath the soil, replant, and we could continue to crop this time after time. Results on As_2O_5, As_2O_3, $NaClO_3$, and Tl_2SO_4 are presented. These were pioneering studies on a method that was eventually to revolutionize weed control. Presently, many of our principal herbicides are used through the soil, and it is becoming more and more apparent that this is the most logical way to use herbicides.

In the Summer of 1932, J. P. Bennett asked us to meet him up in Rock Creek in the high mountains for a vacation period. We drove through Yosemite Valley. We parked our car and had our dinner and turned in to get a night's sleep. There were still bears in the park at that time and a bear had climbed up an old dry snag right near where we were camped. A fellow came out with a flashlight and flashed it on the bear. He climbed up to the top of that snag and then we could hear him let himself down, down, down, scratch, scratch, scratch. Pretty soon, up he'd go again. And so we didn't get any sleep that night. I wasn't worried about Harold, but his mother was worried because of a loose bear in the country. (Laughs) When we got to Rock Creek, we found that the mosquitos were



Alden at Rock Creek, 1937

Crafts: just unbearable and so we had to go back. I took Alice, her sister Marjorie, and Harold back to Davis and, picking up a graduate student, went back up to Rock Creek, over Mono Pass, and camped in the Fourth Recess.

On November 8, 1932, Franklin Delano Roosevelt was elected to office and our daughter, Helen Elizabeth Crafts was born in the Woodland Memorial Hospital. The nurses wanted Alice to call her Rosie for the President, but she had her mind all made up and gave her the name of Helen Elizabeth.

In 1933, Dr. Bennett and I accompanied three women and camped for three weeks in the Fourth Recess. Bennett and I cut wood and fished and the women did the cooking. They had planned the trip well. They were old college friends of Bennett's and had the menus all made out. We had fresh vegetables near the end of the time there because they stored the vegetables in a snow bank. I remember we had steamed fig pudding with rum sauce. That was camping, pretty high camping, I'd say.

When we returned, Alice had had the measles which she got up in Potter Valley when she took Helen up there to leave with her mother. But she recovered although she didn't regain her full health and proved to have a fibroid tumor on her uterus and had to have a hysterectomy. After that she still had ill health and finally, after years of experimentation, it was found that she had a hormone deficiency and several serious allergies.

While we were working, Dick Raynor and I decided to try boron as a weedkiller. I had heard in my work in Hoagland's department in Berkeley that potassium recovered from Searles Lake was being used as a fertilizer, particularly on potatoes. But they were having trouble because they did not take all of the boron out of this fertilizer. So, if boron was toxic, maybe we could use it as a weedkiller. Also Dick Raynor had worked in the boron deposits in the Mojave Desert. Dick and I decided to study boron toxicity. We set up the experiments during the winter of 1933. The results came off on January 2, 1934, the first run. They looked very promising.

In February, 1934, Dick went up to Humboldt County to work on the Klamath weed. He used all the known herbicides plus boron and proved that boron was the most effective herbicide on this particular weed. It could be applied dry, it was washed in by the rain, and it killed the roots. It became used in car-lot quantities in an attempt to stop the spread of Klamath weed. Later, of course, they got the insects in from Australia which really put the Klamath weed under complete control.

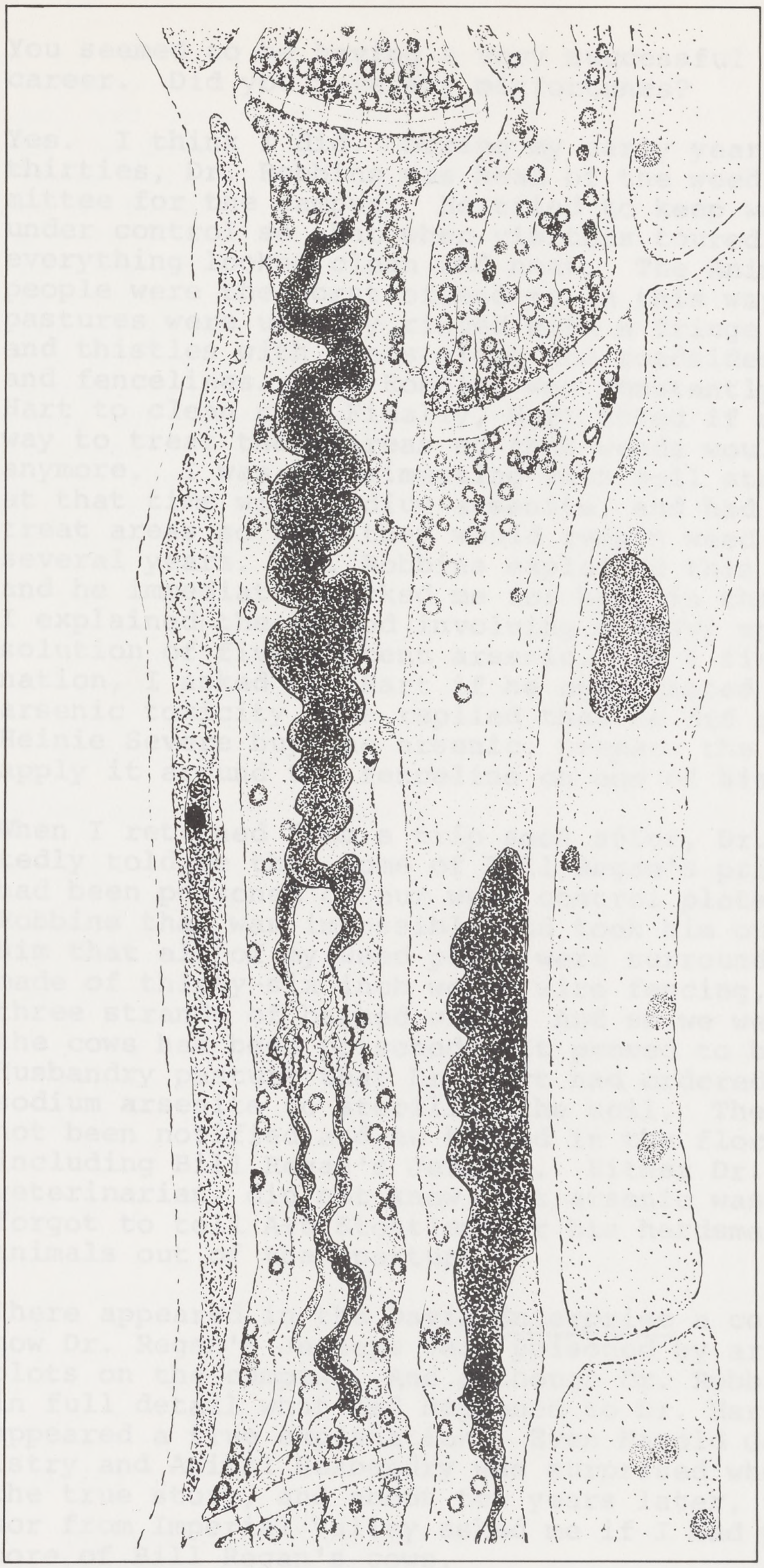


Illustration by A. S. Crafts from his article
"Phloem anatomy in two species of Nicotiana, with notes
on the interspecific graft union,"
Botanical Gazette, June, 1934

Dickman: You seemed to be having a very successful and happy career. Did you have any misfortunes?

Crafts: Yes. I think I did. During my early years in the mid-thirties, Dr. Robbins was head of the weed control committee for the campus. He tried to keep weeds always under control so that when visitors toured the campus everything looked clean and neat. The Animal Husbandry people were the worst offenders in this way. Their pastures were usually ringed with a fringe of foxtails and thistles with weeds along the roadsides, ditches, and fencelines. Dr. Robbins was constantly after Dr. Hart to clean up. Finally, Hart asked if we knew of any way to treat these areas so that weeds would not grow anymore. I was experimenting with soil sterilization at that time with sodium arsenite, and had been able to treat areas so that they would remain weed free for several years. Dr. Robbins explained this to Dr. Hart and he immediately asked me for help in this problem. I explained the method involving a heavy spray with a solution of five percent arsenic. As I finished my explanation, I asked Dr. Hart if he appreciated the hazards of arsenic toxicity. He replied that he did and so Hart had Heinie Severe buy the arsenic, prepare the solution and apply it around the fenceline on one of his pastures.

When I returned from a trip soon after, Dr. Robbins excitedly told me that some of Bill Regan's prize Jersey cows had been poisoned on our weed control plots. I told Robbins that was impossible and took him out and showed him that all of my weed plots were surrounded by a fence made of thirty-six inch woven wire fencing, topped by three strands of barbed wire. And so we went to find where the cows had been poisoned. It proved to be the Animal Husbandry pasture that Dr. Hart had ordered treated with sodium arsenite to sterilize the soil. The herdsman had not been notified and he turned in the flock of cows, including Bill Regan's Jerseys. Either Dr. Hart, a veterinarian, did not know that arsenic was poison or he forgot to tell Art Stottlemeyer his herdsman to keep animals out of that pasture.

There appeared in the Davis Enterprise a column explaining how Dr. Regan's Jerseys were poisoned by arsenic on weed plots on the campus. And although Dr. Robbins explained in full detail what had happened to Dr. Hart, there never appeared a true explanation. Even Harold Goss of Biochemistry and Animal Husbandry was surprised when I told him the true story, and about ten years later, the Farm Advisor from Imperial Valley asked me if I had poisoned any more of Bill Regan's cows.

I'm sure that many of the people in agriculture considered me to be an irresponsible person as a result of this incident. Heinie Severe soon left the University and he told me that this sort of affair was too common on the campus.

Crafts: I had an interesting episode at the time Dick Raynor was working on the Klamath weed. Somebody in the Hawaiian Islands had described soil sterilization below rat baits out in the field. Rats were a serious pest in Hawaii, and these baits had contained thallium sulfate. So Professor S. C. Brooks of the Zoology Department in Berkeley wrote a very serious sounding article in Science warning against the sterilization of soils by thallium. Now Tracey Storer, head of our Zoology Department was very interested in the thallium baits because they were used to kill squirrels in the ranges all over California; the ground squirrels were a host for bubonic plague. This was why Storer was interested in it and they were using these baits. Brooks' warning aroused people very much like the warning sounded by Silent Spring thirty years later. I ran trials on thallium for Storer and we stated in our conclusion:

> Two vital factors are involved in the problem of soil sterilization as related to the control of rodents by thallium-treated grain. The first is the quantity of thallium being placed in the soil for any one area. The second is the final disposition of this poison.

From our quantitative tests, we conluded that:

> The chemical reaching the soil is negligible as compared with that required for soil sterilization.

And we continued:

> It is regrettable that such warnings as those of Brooks and McCool should be issued without some preliminary study of the actual field practice involved.

Sounds very much like the Mrak report. (Laughs)

Alice and I went to Berkeley in the Summer of 1936. I took an apartment on Channing Way and continued my studies on the toxicity of herbicides in soils in the Plant Nutrition greenhouses. Ted Broyer and I studied phloem exudation for a twenty-four hour period in the greenhouses at one time and we published on that later. It could be maintained just by cutting off the end of the squash stem periodically.

After two years in Humboldt County, Dick Raynor returned to Davis where he became a staff member of the Botany Department. Buss Ball, a younger brother of Walter Ball of the California State Department of Agriculture, and

Orville French of the Agricultural Engineering Division did a lot of work on sulfuric acid as a selective spray in cereal and onions. This was supported by money from the Freeport Sulphur Company.

Crafts: In 1937, Sinox was introduced from France. Sinox is dinitro ortho cresylate. It came from France and proved to be a very effective weedkiller. Raynor and Westgate worked on this and they published a bulletin in 1937.

In 1937, we bought ourselves a new Ford V-8, the little V-8 that they put out, and took a sabbatic leave to Harvard.

I had been working with I. W. Bailey on the phloem in the plant world while at Harvard. Bailey had a farm on the Massachusetts coast and when we went down there, I performed some experiments on his white pine trees and found that I could get phloem exudation from white pine. Later I saw the same sort of thing with sapsuckers on our campus here; we were getting phloem exudation which dropped down onto the sidewalk.

We came home from that summer at Harvard along the East Coast. Through New Orleans where we experienced a severe storm; we came on through Baton Rouge and Shreveport. While we were coming home that summer, we figured that we were paying rent on our house in Davis, which we had sublet. Friends of ours having heard that this house had been sold had rented a second house for us. We were still paying rent on our Cambridge apartment and we were paying for a motel every night--four rents every night. So we decided then that we were going to build our own home; we were through renting. So we built a home at 626 "B" Street. I sold my Leica camera for twelve hundred dollars and that was the start of the purchase of a lot on which we built this house.

My brothers had sold the farm in Potter Valley, and so mother came and lived with us until 1942. Also in 1942, Weed Control, published by McGraw-Hill and authored by Robbins, Crafts, and Raynor appeared on the market; the first college-level textbook on weed control.

VII. THE WAR YEARS AND PUERTO RICO

Crafts: Now, along came December 7, 1941, Pearl Harbor; we were at war and our campus was taken over by the Signal Corps. My research was not disturbed though and I continued to work on dinitro compounds. We got a whole series of samples from Dow Chemical Company of various dinitro compounds and I was able to show that dinitro secondary butylphenol was the most toxic of any of them. And very soon, the Dow Chemical Company put out Dow Selective and Dow General herbicides and the Standard Agricultural Chemical Company put out Sinox General.

Then we worked on the fortified oil emulsion. We found out that if we put pentachlorophenol into an aromatic oil with a wetting agent we could dilute this out and use it as a contact spray.

Reiber and I worked on oils. I got samples from many companies and studied all of the types of oil that we could get. Diesel oil had been used on roadsides for years and it was found during the war that stove oil was selective; it would kill the weeds out of carrot crops. We tested all these oils and found that the aromatics were the toxic part and the aliphatics were bland. When I mixed ten percent of an aromatic oil and ninety percent of a bland oil, I got the same results on carrots; that is, it took over ten percent aromatic to kill carrots. Soon the oil companies put out special carrot oils and they found that Stoddard solvent, the standard cleaning mix was also effective on carrots. They also produced a selective oil to kill weeds out of flax at that time, because flax was being grown during the war. So we worked through those years particularly on oils.

A weed control course had been instituted and Raynor had taught it until the time of the war. After the war, I took the course over and instituted a field exercise on Saturday mornings. During those years Chet Cleary came to work for me. We did some work in the greenhouse on the interrelations and combinations of arsenic, borax, and chlorate in soils. We published in December, 1936, on "Synergism and Antagonism and Additive Effects in Soils."

During the war Alice taught at the Fairfield School in Davis and my mother moved down to Plainsburg to live with my sister Dorothy.

In 1945, Bill Harvey came from Prosser, Washington. He was educated at Ames and worked with Bakke at Ohio on a project financed by the Chipman Chemical Company on sodium chlorate. Very soon our weed control work was becoming so widely disseminated that we needed some extension. So Robbins pressed Harvey into this extension work and Bill worked at this for a number of years. Then in the mid-forties he took out three years and went to the Monsanto Company. But he didn't like industry; it was too high pressure, so he came back. In the meantime we had been awarded the position for a weed control specialist in botany and Harvey took this position and became well-known as one of the best weed control specialists in the country. Harvey, Dutch Sylwester, and Walter Ball developed the weed conference concept, and the California conference was held first in Sacramento in 1949 and the Weed Science Society of America had its first conference in 1954 in St. Louis, Missouri.

Crafts: During the war we continued work on the oils and in 1944 we published; again in 1948 we published in Hilgardia, Crafts and Reiber on the "Herbicidal Properties of Oils."

In 1944, 2,4-D came along. Hamner and Tukey published in Science on the effect of 2,4-D as a plant hormone in weed control, and very soon the whole field of weed control was revolutionized.

We obtained our first sample of Weedone from the American Chemical Paint Company in the Winter of 1944 and I put it out on some bindweed plants. The results were not particularly effective because we got it on too late in the year. The first 2,4-D came out in the formulation with Carbowax. Professor E. J. Kraus had worked with the U.S. Government at Beltville on 2,4-D as a weedkiller and found that it was effective. The government had purchased a number of tons of it and it was going across the Pacific Ocean at the time of the armistice for spraying vegetation on the bypassed islands in the Pacific. When the war was declared over, they turned that shipment around, brought it back to California, and the chemical companies purchased it, mixed it with either sodium carbonate or sodium bicarbonate and put it on the market.

The 2,4-D weedkiller was very effective and quickly became popular. The acids and the salts and the esters were all put out on the market. We soon ran into the problem of spray drift to nontargeted crops; grapes, tomatoes, and cotton were the most sensitive crops. They tried the dust in the southern states on weeds in cotton and found that it drifted for miles so that it was soon outlawed. 2,4-D was a translocated spray; that is, if you put a few drops on a leaf, they would penetrate into the leaf and move around inside the plant and so the high volume recommendation used for sulfuric acid and Sinox was not required.

Crafts: Very rapidly there developed the low-volume application where with water you could apply five gallons per acre. With oil, the esters could get down as low as one gallon per acre. And so it went from thousands of acres to millions of acres within a matter of two or three years.

In Canada they took big twin-engined bombers and adapted those to use in weed control. They could do this particularly where there were no susceptible crops around, for instance in the Palouse district in Washington and the plains of Canada. One of these twin-engined bombers could take up a thousand gallons and spray all day long with it.

Two, 4-D was widely used in California on cereals including rice. Soon many court cases appeared from injury to grapes in Lodi, tomatoes in Woodland and Sacramento, and to cotton in the San Joaquin Valley. Realizing the seriousness of the situation, I wrote a paper "The 2,4-D Weed-killers, A Warning." I sent this into Science and was surprised that it was turned down for lack of space. So I gave this to Walter Ball and he had it published in the Bulletin of the State Department of Agriculture. It was widely disseminated simply warning people that this new chemical had dangerous aspects that had to be considered.

About this time the idea of preemergence weed control became popular. And the first preemergent sprays were oils used in onion crops. They were applied after the seeds were in the ground but before the onions got up. The weeds would always get up ahead so that they could spray out and kill the weeds without hurting the onions. And then they tried Sinox on onions and this proved to be quite effective.

Raynor and I worked in the greenhouse on this. We very soon found that if you use a water-soluble salt as a preemergence spray and there was rainfall afterwards so that the young plants pushing up through this soil would come in contact with the chemical, they would be killed. So again, I put out a paper in August, 1944, warning against the use of water-soluble chemicals applied preemergence. It was perfectly all right if the soil remained dry but if they had rain or heavy dense fog, it would moisten the topsoil; then the young shoots pushing through the soil would be injured.

When Anderson and Algren recommended 2,4-D as a preemergent spray for corn about 1947, I published again in Agricultural Chemicals on the possibility of pitfalls in this method.

All during these years Alice continued to have health problems. She had met Marion Conrad and they had tried putting Harold on an elimination diet because he had croup periodically. We soon found out that when wheat was taken out of his diet the croup disappeared. He was allergic to wheat. I tried the diet and found that I was also allergic to wheat and we lived for several years on a wheat-free diet.

Dickman: When did you take your sabbatical leave to Puerto Rico?

Crafts: In 1947 I took a sabbatic leave to Puerto Rico. We went by train, stopping in Jacksonville, Florida, where the army engineers had a project on water hyacinth control which they were controlling with scythes, with saw boats and with chains. I went out and saw all these experiments and realized the seriousness of this problem. The river there had been completely choked up so that it was no longer navigable because of the water hyacinth.

We went on to Miami, stayed overnight in a hotel, gave the kids a chance to swim in the surf and then flew via Cuba and Santo Domingo to San Juan, Puerto Rico.

I worked at the agricultural experiment station in Rio Piedras. We lived in a Pullman-type apartment on the south side. You can appreciate that if you've ever lived in Puerto Rico because it's hot.

The children went to school. The teaching was in English but all the conversation was in Spanish and so they had to learn how to understand their Spanish schoolmates. We enjoyed the beaches and stayed healthy.

Van Overbeek and Velez had introduced 2,4-D into Puerto Rico to kill daylily or *Commelina*, a serious weed pest in the sugar plantations. And this had been successful in eliminating *Commelina*. So that, with more light in the sugar cane fields, grasses started to thrive and therefore the problem was even worse than it was before. So I brought in the fortified oil emulsion as the answer to this problem.

There was a young Puerto Rican professor in the Agronomy Department, Aurelio Emanuelli, who was just home from four years at Cornell. We got together sprayers and drums and the necessary chemicals and established demonstration trials all over the island of Puerto Rico. We could kill the annuals, most of which were grasses. We could kill the foliage of the perennials which was cheaper and easier than cutting with machetes the way that they did it there. We also treated ditches, ditch banks, roadsides, and storage areas.

Crafts: We made one unexpected discovery. Mixtures of two or more herbicides may save one spraying operation. So it was very often used, but the recommendation was not to try mixing chemicals if one of the materials was a translocated spray because the contact spray would kill the leaves and that would prevent translocation. However, when we tried putting our fortified spray on grasses and *Commelina*, the *Commelina* leaves would be killed but there was resprouting from the nodes of the *Commelina*. This was a case where the theory was okay, but it was best to go out and test in the field to make sure that you weren't dealing with something unusual.

Two, 4-D can be used as a preemergence spray but is subject to leaching. Acids or esters were best under heavy rainfall conditions and the sodium salt best under restricted rainfall. It was a matter of solubility. The introduction of the general contact sprays at that time was a milestone in the use of chemical weed control in the tropics because we had an answer to both perennial and annual weed control.

While I was in Puerto Rico I read the galley proof of a book that I had written along with Herb Currier and Ralph Stocking and about the time I got home this book came out, Water in the Physiology of Plants, by Crafts, Currier and Stocking, 1949.

We had a good time in Puerto Rico but as we were about to leave, Harold went to a school picnic and drank some of the punch which we had warned him not to do. On the boat he had a bad time for a couple of days but he recovered all right, the boat's doctor took care of him. On the way home we stopped on the far side of Cuba at Caibirian and took on a load of sugar. The sugar was being brought out to the boat on ketches, that is flat bottom boats with sails. And every morning as we got up these ketches would be seen coming from the town out to the boat with their loads of sugar. I got a beautiful photograph of those which I enjoy very much.

During our last days in Puerto Rico, Dr. Robbins and his wife Barbara stopped by on the way to give lectures about weeds in various places in South America. He was sent by the U.S. Department of Agriculture.

On our way home, the boat arrived in New Orleans. We went by train on up to St. Louis, Missouri, where I visited the Monsanto Chemical Company and saw the work they were doing on herbicides in the greenhouses. By the way, Monsanto sold the pentachlorophenol that we were using in Puerto Rico. I saw their greenhouse work and their experiments. Then we proceeded home on the "Spirit of San Francisco."

Crafts: Back from Puerto Rico, we turned in our Ford V-8 for a six-cylinder DeSoto, a car the kids in high school would not be ashamed of.

When I got to Davis I served as Chairman of the Botany Department while Robbins was away. I hired Ernie Gifford during this period at the recommendation of Adriance Foster in Berkeley. He proved to be a very, very useful member of our department.

After my stay in Puerto Rico I received a letter from Arturo Roque the Director of the Agricultural Experiment Station at Rio Piedras. (See Appendix F).

VIII. FINAL PROFESSORIAL YEARS

Crafts: The California Weed Conference was organized in 1949. The first meeting was held in Sacramento on February 16 and 17. Walt Ball was the president and I served as the chairman of the research program and gave a paper on the "Chemistry of Weedkillers." The subject was later introduced into Chapter 9 of our book Weed Control which was revised in 1952. I also gave this as a general address before the Northcentral Weed Control Conference at Sioux Falls, South Dakota, on December 6-8, 1949.

I had a very interesting experience there. In the basement of the big exhibition hall they had many displays including some on books. As I was walking past the book display with Dr. Willard from Ohio I asked Willard, "How do you like our book Weed Control"? Willard was an agronomist and I can understand his answer. He said, "I don't like it at all. It has only one page on weed control in corn." "But," I replied "if you have read the preceding pages, that is all you need." What Willard wanted was a cookbook sort of thing where he could look up on a certain page and find the recipe for killing weeds in corn.

The second California Weed Conference was at Pomona on April 4-6, 1950. I reported on our current research. There was discussion of the best formulation of 2,4-D. I pointed out that the research indicated that the 2,4-D acid was the best form and I suggested a micronized acid in oil emulsion.

Soon the America Chemical Paint Company put out a suspended 2,4-D acid in nontoxic carrier; this proved very superior in brush control. Formula 638 became standard practice for controlling brush with 2,4-D. The 2,4-D acid particles are trapped on the cuticle; they dissolve and move on in, and so are extremely effective.

In Pomona I was elected president for the third California Weed Conference to be held in Fresno on January 30 and 31, 1951. At this conference Paul Sharp gave the opening address, "Research on Weed Control," and agricultural extension director Earl Coke gave a talk on "Progress in Weed Control." Walter Ball told of the program of the California State Department of Agriculture. Weed control was becoming recognized as an essential technique in crop production in California.

In 1951 I was elected secretary of the American Society of Plant Physiologists where I served for two years. Then I became vice-president in 1954 and 1955, and finally president in 1955 and 1956. I attended four meetings of the national society driving across the country each time.

Crafts: At the fourth meeting of the California Weed Conference in San Luis Obispo on January 26, 1952, I talked on the "Physiology of Herbicidal Action." We had one session on plant ecology in weed control.

Dr. Robbins retired in 1951 and Vernon Cheadle had been visiting, working with Dr. Esau. Dean Hutchison's committee to find a new chairman for the department selected Cheadle to succeed Dr. Robbins and Cheadle was happy to accept the position but was committed to return to Rhode Island for a year. So, Hutchison asked me to serve as chairman which I did in 1951-52.

In the 1930's and 1940's the interest in brush control in California had become very intense. Merton Love, a leader in this research in brush control found out that when brush and trees were removed, the grass thrived, springs appeared that had not flowed for years. Now, when Paul Sharp, Director of the Experiment Station, bought a hill range near Sonora, he found much of his area covered with brush. We had been requesting a man to work on woody plant control and in 1949, Sharp created a position. I had met Oliver Leonard at Mayaguez, Puerto Rico in 1948 and I knew of his work at Washington State University. So I recommended to Dr. Robbins that he try to hire Leonard. He was in Mississippi at the time but he was happy to accept the position in Davis, and he came here in February, 1950. Oliver tackled the job with vigor and by treating with 2,4-D each month of the year, he found within a year that the treatment in the early spring was much more effective than treatment later on at the blossoming period which had been recommended in the previous publications. It was a problem of translocation. The roots start to grow early on these perennial plants like live oak and manzanita and that sort of plant, and they're using food materials so that food materials are moving down. Later when the plant comes in blossom, the food materials are moving up and the sprays are not effective.

Oliver also developed the injection method for killing unwanted trees which became very widely used. He used an undiluted amine formulation in the cuts. He treated thousands of plots of seedlings and resprouts of woody species. He worked with the extension service, the State Department of Forestry and the Bureau of Land Management. He worked with the public utilities and he worked with the ranchers. Thousands of acres of brushland are being cleared each year using methods developed by Oliver Leonard.

In 1951, Max Kleiber had been using radioisotopes to study metabolism in cows. Dr. Sharp recognized the great usefulness of such work. He suggested to me that we obtain a project from the Atomic Energy Commission to study absorption and translocation of herbicides in plants using labelled tracers. We applied and were granted a project and started work in July, 1951. This was to be the most exciting and gratifying work in my whole career. The project carried on until I retired in 1964.

Crafts: At the start of the Atomic Energy Commission Project, Dr. Leonard, Charles McCarthy, a research assistant, Doug Stewart, a lab technician, and Wallace Orgell, a graduate student were involved. We had been studying translocation of 2,4-D using the bean bend test as an index of movement. For instance, Boysie Day did his Ph.D. research by this method.

Our first experiments repeated this work using carbon 14 labelled 2,4-D. We soon proved that wherever we had formative effects from 2,4-D, the C^{14} was present. Our plans included use of various labelled compounds to study uptake and transport of herbicides in plants. Our first annual report revealed that light was essential to the bean bend response and we built a bank of florescent lights in the greenhouse so that we could standardize light exposures. Available water also proved essential to rapid uptake and transport. In January, 1952, we had our lab equipped and the studies with labelled compounds started in earnest.

We developed autoradiographic methods using freeze-drying of the plants to avoid the artifact of xylem movement. A steel vacuum chamber was built with trays to hold the plants, the plants were put in the trays, dry ice was placed on top of the plants and the whole vacuum chamber was sealed up and put into the refrigerator. A vacuum hose went through the wall of the refrigerator to this vacuum chamber and the plants were dried under a vacuum. When they were completely dry, we took them out of the chamber, remoistened them slightly to avoid shattering of the leaves, pasted the plants down on paper, pressed them in a heavy press so that they were perfectly flat, placed them on X-ray films and after several days, we developed the films. This film showed the exact location of the tracer. We used tracers including toxic herbicides that should have been unable to move in living phloem, and we proved that these toxic materials moved the same as food materials in the plant.

We proved that all phloem mobile compounds moved by mass flow with the assimilates in the phloem at velocities up to a hundred centimeters per hour. They moved out of green leaves but not out of chlorotic leaves. By contrast, they moved into and accumulated in chlorotic leaves. Movement goes from source-to-sink along a gradient of osmotically active substances in the assimilate stream.

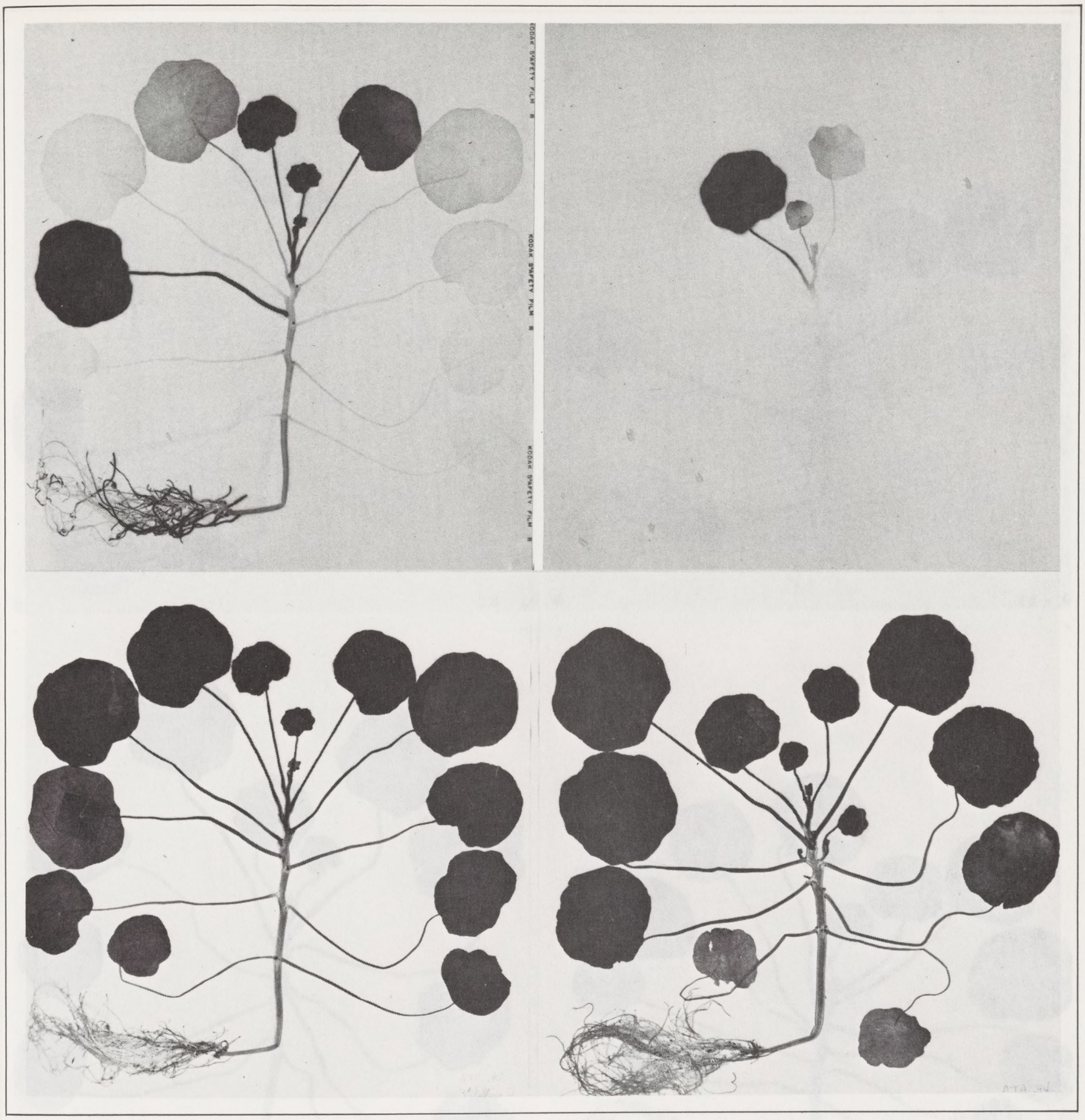
Crafts: In 1954, I gave the faculty research lecture on the topic, "Chemical Weed Control, Applied Plant Physiology." Using slides of our own radiographic studies, I explained the uptake and movement of herbicides by plants.

In 1954, the Eighth International Botanical Congress was held in Paris. When the time grew near, Alice and I picked up our daughter at Occidental College in Southern California, drove on past New Mexico where our son joined us and we visited in Lincoln, Nebraska with the Cecil Blunns, friends of ours from many years back. Alice, Helen and I drove to New York, boarded the United States Steamship "United States" to LeHavre, France, then went by train to Paris. We stayed in a little hotel on the east side along with Katherine Esau. This hotel had been recommended to us by Miss Bjerlicke, a Norwegian librarian who had been at Davis.

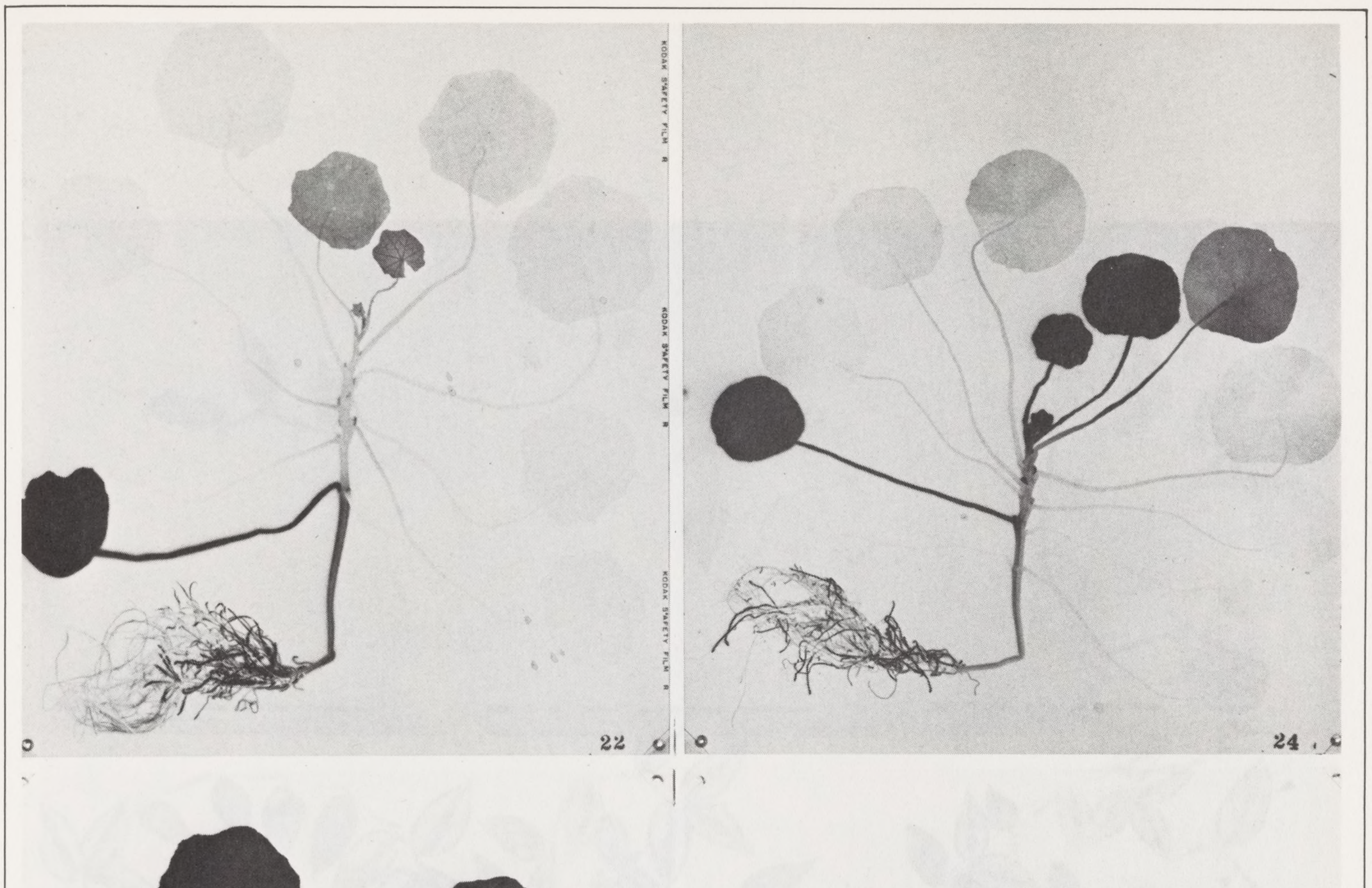
I attended the Congress and gave two papers and learned the difference between comfort stations in France and in the USA. The final evening in Paris we went to the opera. I was surprised by my ability to obtain what apparently were excellent seats, but when we got there, we were directly behind a pillar six feet in diameter!

On July 14, we rented a Citroën car and set out for Amsterdam. We had a fine time driving across France through Switzerland, Austria, West Germany, to Amsterdam. There Wybo van der Zweep, a former student in the Botany Department served as our guide. We visited Wageningen where Wybo worked, crossed the dam of the Zwieder Zee, visited a polder, and finally dined at the Five Flies of Amsterdam, a famous restaurant.

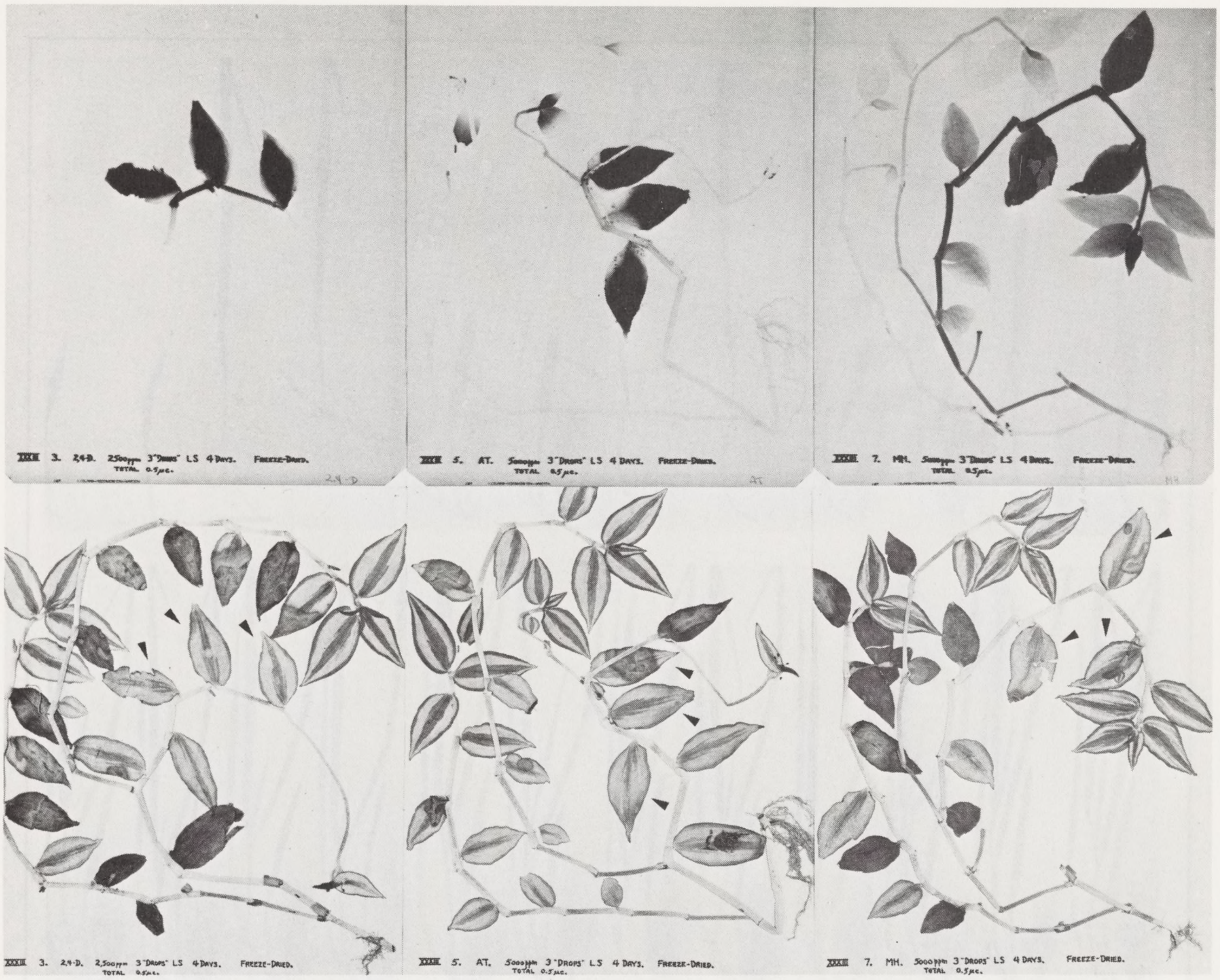
We took the train to Copenhagen and on to Gottenburg where we took the Gotä Canal trip to Stockholm. We enjoyed this trip. It was a small boat and it went along slowly so that we could get off at one lock in the Canal and walk alongside on the bank up to the next lock. We enjoyed this trip very much. In Stockholm, we met Ove Hall, a young man whom Helen had met in Paris. He immediately made a date, took Helen to shows, dances, and to dinner. We visited the Lundegardhs in Penningby. He was a friend of Professor Hoagland. He took me out on the Baltic Sea right near his house in an outboard motorboat. After the Lundegardhs, we took the train to Oslo. Miss Bjerlicke, the Norwegian librarian who had spent a year in Davis and lived in our home, met us and served as our guide and companion. We visited Viegland Park and in the evening attended the opera "Tosca." We saw the folk museum in Oslo and went by train to Bergen. By boat we went to Newcastle from whence we went by bus to Edinburgh. We took a tour through the Trossachs into the beautiful lake



Movement of ^{14}C-labeled amitrole from leaf no. 6 (left) and leaf no. 9 (right) into active sinks in growing tissues. From leaf no. 6 transport was both upward to growing leaves and downward to the roots. From leaf no. 9, which was still dependent upon the lower mature leaves for its organic foods, very little transport took place; that tracer which moved from the leaf went to even more actively growing apical leaves.



Movement of ^{14}C-labeled amitrole from leaf no. 1 (left) and leaf no. 4 (right) into actively growing plant parts of nasturtium. Actively photosynthesizing leaves are largely bypassed.


XXXII 3. 2,4-D. 2500ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.
2,4-D
XXXII 5. AT. 5000ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.
AT
XXXIII 7. MH. 5000ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.
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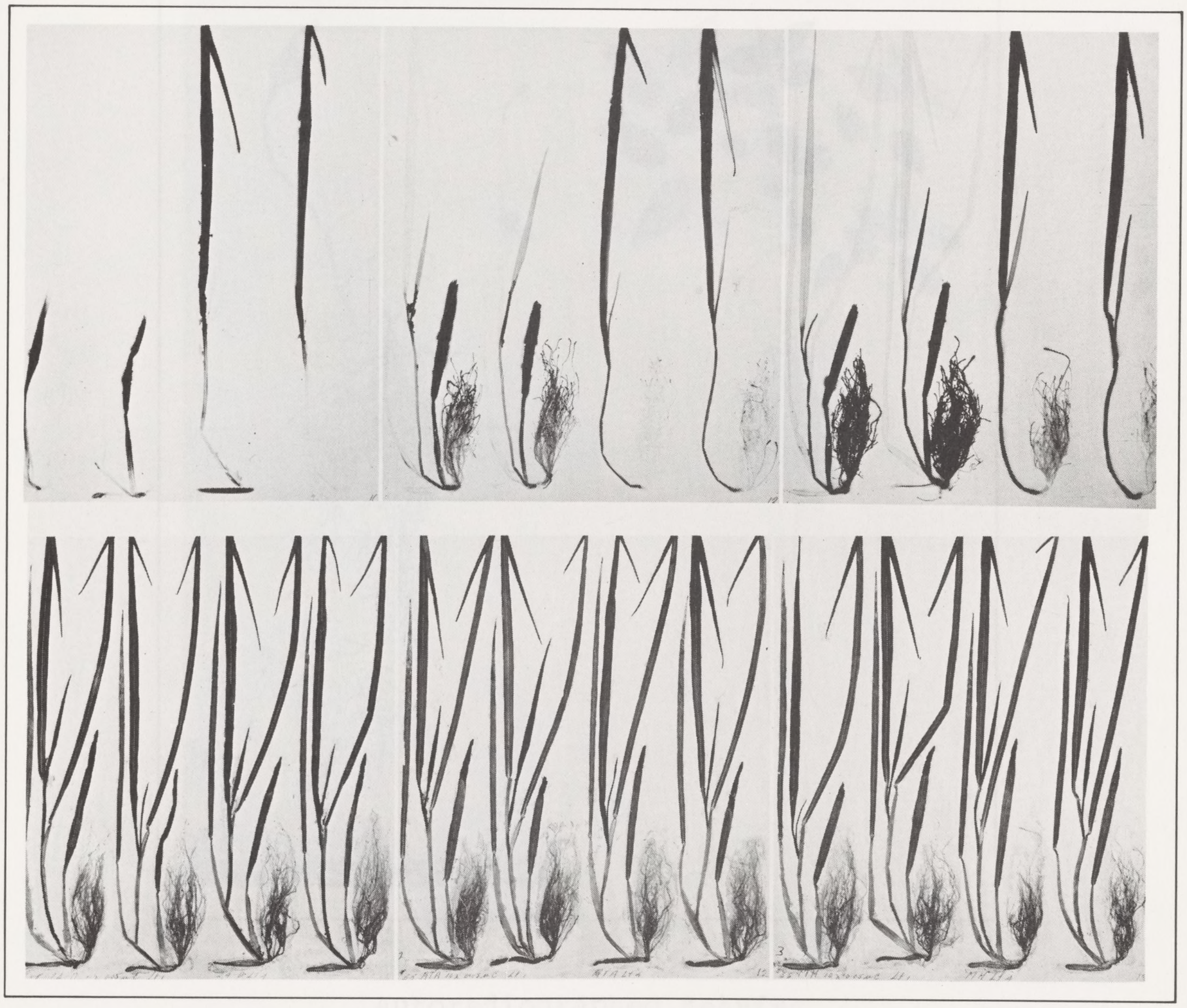
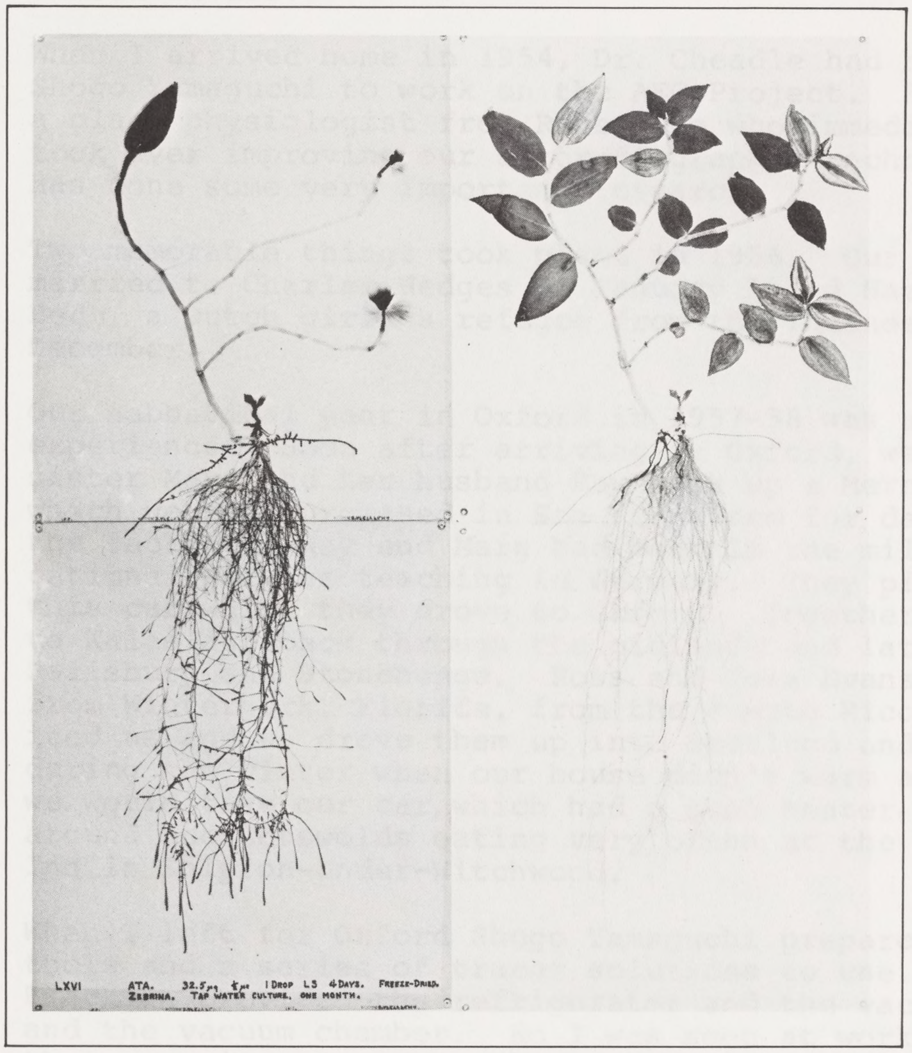
XXXIII 3. 2,4-D. 2,500ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.
XXXIII 5. AT. 5000ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.
XXXIII 7. MH. 5000ppm 3"DROPS" LS 4 DAYS. FREEZE-DRIED.
TOTAL 0.5μc.

Autoradiographic studies of the effects of 2,4-D
aminotriazole, and maleic hydrazide on a wandering jew plant



Autoradiographic study of the effect of 2,4-D aminotriazole, and maleic hydrazide on barley


LXVI
ATA. 32.5μg ¼μc 1 DROP L5 4 DAYS. FREEZE-DRIED.
ZEBRINA. TAP WATER CULTURE, ONE MONTH.

Autoradiographed *Zebrina*

country and enjoyed the Edinburgh Music Festival. From Edinburgh we took the train to London and then on to Oxford where we visited with Geofrey Blackman. And I arranged at this time to take my sabbatical leave at Oxford in 1957.

Crafts: When I arrived home in 1954, Dr. Cheadle had hired Dr. Shogo Yamaguchi to work on the AEC Project. Shogo was a plant physiologist from Riverside who immediately took over improving our autoradiographic technique and has done some very important research.

Two memorable things took place in 1956. Our Helen was married to Charles Hedges on January 1 and Harold married Bedo, a Dutch girl, a refugee from the Indonesian war in December.

Our sabbatical year in Oxford in 1957-58 was a beautiful experience. Soon after arriving at Oxford, we had Alice's sister Marg and her husband Ray pick up a Mercedes 220S which we had purchased in San Francisco for delivery at the factory. Ray and Marg had been in the military educational service teaching in Germany. They picked up this car which they drove to Oxford. Together we drove to Wales and back through the midlands and later to Salisbury and Stonehenge. Ross and Cora Evans, friends from Winterpark, Florida, from the Puerto Rico days, visited us and we drove them up into Scotland and back. Often during the winter when our house didn't warm above 50°F we would take our car, which had a good heater, and drive around the Cotswolds eating very often at the Shaven Crown Inn in Shipton-Under-Witchwood.

When I left for Oxford Shogo Yamaguchi prepared a kit of tools and a series of tracer solutions to use. Dr. Blackman provided the refrigerator and the vacuum pump and the vacuum chamber. So I was soon at work doing further experiments on the absorption and translocation of herbicides labelled with C^{14}. During the year I prepared three papers on the comparative mobility of labelled tracers. One paper gave evidence for hydrolysis of the esters of 2,4-D during the absorption process by the plants.

Before leaving for Oxford I had agreed to relieve Leonard Machlis of his job as editor of the Annual Review of Plant Physiology. This was an added obligation to keep me busy. What follows is the Preface of that publication.

* * *

> The sabbatical leave is a wonderful institution. It is time for reorientation, for reflection, and for housecleaning. For a visiting American, a

sabbatical leave at Oxford is particularly gratifying. To walk through the University parks; to watch soccer, rugby, and hockey on the playing fields; to follow the punts as they glide along the Cherwell; to listen to the bells at eventide; these are rare pleasures and one needs time to appreciate them. And for one interested in science, to chat with C. D. Darlington, to plan experiments with G. E. Blackman, to talk shop with W. O. James and Robert Brown, Scott Russell and E. K. Woodford, and a host of others; these are the privileges of a year at Oxford.

Oxford is venerable with age that dignifies and lends stability. And Oxford is new with the enthusiasm of youth. To hear the debate on the advisability of constructing a ten-story building on the Keble triangle that will "change the Oxford skyline," and to hear the discussion on the proposition to make Latin optional for college entrance are novel experiences for one from California.

Sitting in my pleasant living room with the sunlight streaming through the broad windows, I look out on a typical English garden. Many of the trees are one hundred years old or more; the gravel walks have been here for many generations; the sundial and the rain gauge are permanent accessories. A thing of beauty, this traditional garden has its roots in an historic past. In a California climate these trees and shrubs would have matured and declined and probably have been replaced several times in the same span of years. Such are the differences one finds in traveling from the New World to the Old.

As I gaze on the dome of Radcliffe Camera and study the beauty of the Divinity School and glimpse the grizzled faces of the philosophers around the Sheldonian I am duly impressed with the antiquity of Oxford. But, scanning the sky, crisscrossed with vapor trails of jet planes, I sense the spirit of unrest and change inherent in Man's nature. Sputnik, Zeta, China, Indonesia, Sudan, Summit. Latin has been required for entrance at Oxford. What about science, sociology, politics? And where, in this day, stands the role of tradition?

Oxford is known for its long history of scientific progress. The Clarendon Laboratory has done much work on atomic structure; today its research in the field of low temperature is outstanding. The old school of rural economy has changed into the Department of Agriculture with emphasis on agricultural science; now it has a large group devoted to the biological application of isotopes. Here is tradition of a sound and basic sort, unswayed by the shallow popularisms of the day, confident from centuries of experience that it can meet the problems that lie ahead. Tradition, it seems to me, is of value when it stands for stability and thoroughness. But tradition for tradition's sake has no place; there is too little room for the ever-increasing mass of new information. Foundations we must have, but change we must have also. Change, discard, housecleaning.

We all like popular things and it is good that popularity brings intense study. But popularity fades, emphasis shifts, and new interests take over. During my years I have witnessed the ebb and flow of many emphases in the field of plant physiology. Permeability, inhibition, Donnan equilibrium, pH, auxin a and auxin b, rH, minor elements, mitogenetic rays, solarization, active water, coacervates, vernalization and photoperiod; these and many others have known the spotlight. Some are still popular, others have faded from view. Each has left its mark, many positive, some negative. And so our science has grown, becoming deeper and broader and ever more firmly planted in modern living.

Progress, it seems to me, must build on the old; make room for the new; and always keep the two in balance. Tradition has its place but so has progress. In studying the architecture of cathedral spires we must not neglect the vapor trails. While studying bound water we must save some time to consider free space. And in our fervid attempts to solve the problems of particulates we should remember the complicated procedures we have used to free them from their natural environment in the organized plant. Annual Review of Plant Physiology earns its place in the field of biology if it does no more than present, each year, a broad and well balanced view of progress in this dynamic branch of science.

Last year I paid tribute to the faithful work of the Editorial Committee. Now I feel compelled to acknowledge the very great help of the assistant editors. Being permitted to edit a volume of Annual Review of Plant Physiology while on sabbatical leave is a rare privilege and only through the forbearance of Leonard Machlis and John Torrey was this possible. Dr. Machlis organized and chaired the annual meeting of the Editorial Committee that set up Volume 11 at Stanford. Dr. Torrey hurried home from his sabbatical leave at Cambridge to be present and help in the procedure. And Dr. Torrey is "holding the fort" in California while both Dr. Machlis and I spend sabbatical years in Europe.

The long and valuable help of Dr. James Bonner is recognized as he retires from the Editorial Committee. Dr. Anton Lang will be the new member. Mrs. Sonya Pinney worked as editorial assistant in the handling of Volumes 8 and 9; she is now succeeded by Mrs. Florence Dick; both these people have rendered invaluable service in the organization and editing of these volumes.

A. S. Crafts, Editor
Oxford, England
Spring, 1958

* * *

Crafts: At the end of our sabbatic leave we drove around Ireland, across England to Dover, across to Calais and through France, Switzerland, Austria, Germany, and back to Rotterdam, where we put the car on a boat. Alice and I took the boat to Portsmouth, England, where I took a train to London. Alice stayed with the car to the USA. From London, I flew with Ken Woodford to take part in Blackman's group on the first African Weed Control Conference in Victoria Falls.

On this trip we visited the Rift Valley where we saw alfalfa being grown to feed race horses, in which weed control was performed by women. The price of the hay was measured by the number of woman hours required to grow it.

At a stopover in Khartoum we saw a British Comet being tested. This of course was before the days of the famous Boeing jet planes. On our trip back from Africa, our Britannia developed engine trouble and we had to return to Salisbury. The next day we boarded a Viscount plane

Crafts: and flew all day. In the evening, landing in Khartoum, there was a bump on one of the wings and we found later that we had hit a burro on the runway. Next day we flew to Benghazi and on to Rome. Here my booking ran out. But during the discussion in the office, a Britannia flew in, the alternator had been flown up from London and installed and the Britannia was now here in Rome. I boarded it and went on to London. I took an overnight flight to New York and proceeded to Newark, New Jersey where Alice and the Mercedes awaited me.

During Alice's trip, grandson Michael Crafts arrived and while we were in Beltsville, Stephen Hedges arrived; so we started home. It took us just four-and-a-half days from Washington to Davis to get home to see our two new grandsons.

Work on the autoradiography was proceeding well. I had the major job of the revision of Weed Control which was published in 1952. In 1959, Cheadle decided on a sabbatical leave. We had been building the present Robbins Hall and when he left, we soon started moving in. That was June, 1960. Dean Young had asked me to serve as chairman during Cheadle's absence and I had the responsibility of overseeing the move. I published seven papers in 1960 and four in 1961 including two short books. When Cheadle returned, Young asked me to continue as chairman. Cheadle was negotiating for the Chancellorship at Santa Barbara. I served as chairman until July 1, 1963, when Ernie Gifford took over. I was slated to retire in 1964.

In the summer of 1961, we had attended the Pacific Science Congress in Honolulu. They had a session on weed control in this Congress and then we proceeded under the guidance of Noel Hanson on trips to the four different islands on each of which we gave a series of talks and discussions on weed control.

In 1962, I authored six publications, one of which was Weed Control, Edition Three. We had a trip to South America in 1962. I attended the Weed Conference in Brazil near Rio de Janeiro and I visited with one of our former students, Otto Anderson, who lived there. Then later on we visited Santiago, Chile and flew on to Venezuela where I gave a series of lectures for the Servicio Shell, agricultural experiment station of the Shell Oil Company.

Alice came home to help David Rincon, a graduate student, get established for graduate work. I was taken by land rover into the high mountains and into various agricultural areas in Venezuela.

Crafts: During all this time, Dr. Esau had been working on phloem anatomy with the electron microscope. Mark Engleman working with Katherine conceived the idea of killing the phloem without cutting it in any way, by injecting the killing fluid into the hollow peduncle of a squash. And lo and behold, when this was done, the pores in the sieve plates were free of the plugging materials. Phloem anatomists failed to realize that they had provided an answer to the hundred-year-old enigma of the mechanism of phloem transport. Plugs proved to be an artifact resulting from the cutting of the tissues to prepare them for observation under the microscope. Currier and I published in 1963, pointing out the significance of this remarkable finding.

I retired as of June 30, 1964, and having two months vacation saved, Alice and I took off, on May 1, for a sixteen-month tour around the world.

On my retirement, I received many communications from former students and colleagues. (Some of these are reproduced in Appendix F).

My retirement was celebrated at El Rancho Inn in Sacramento. There were over 100 in attendance and we had a wonderful time. As indicated above, Alice and I had a tour of Europe following our year in Oxford. As indicated, we had an even more extensive trip in 1964-65, finally encircling the globe.

Some of the most gratifying experiences a teacher can have are to visit his former students in their native environments and observe the effects that their training has had on their careers. My travels have been especially rewarding in this way. In 1954, in 1958, and again in 1957-58, I was able to visit many of the foreign students who had taken courses in Plant Physiology and Weed Control at Davis. In every case this experience was gratifying.

In 1954, Alice and I and our daughter Helen, who had just graduated from Occidental College, attended the Botanical Congress in Paris and then drove to Amsterdam where we were met by Wybo van der Zweep, who served as our guide. Wybo had finished his work for the Ph.D. degree under Professor H. B. Currier, and I had served on his final committee.

In 1958, after my work at Oxford, Alice and I visited Wybo again in Wageningen and at nearby Arnhem we stayed with Emilio Levy who took a Master's degree with me.

Crafts: In 1962, at the meetings of the Pacific Science Congress in Honolulu, several of my former students were in attendance. Later that year on a trip to South America, we stayed with Otto Anderson and his wife in Brazil, and later with David Rincon in Venezuela. Jose Pereira we saw in San Jose, Costa Rico.

In 1964-65, Alice and I visited with Wybo and Emilio in Holland, with Emilio again in Geneva, Switzerland, with Tino Rebeiz in Beirut, Lebanon. In Israel we contacted Naphtali Tadmor, who had taken a degree in the Agronomy department at Davis, and Nora Reinholt whom I met in Dr. Blackman's department at Oxford. In Perth, Australia, Jack Lonneragan met us at the boat, in Melbourne we visited with old friends, the Bill Parsons who had spent a year in the Botany Department at Davis. In Canberra, the Greenhams who also had been a year in Davis, arranged us rooms in a dormitory for us and in New Zealand, we stayed with Bernard and Margo Forde who had obtained his Ph.D. degree with me at Davis as had George Mason of Ivon Watkins-Dow, a company that specialized in herbicides.

On a trip which I made in 1969 I visited with friends in Tokyo and Kyoto, Japan, in Laguna, the Philippines, and in New Delhi, India, all people who were interested in autoradiography of plants, particularly weeds. In Stellenbosch, South Africa, I stayed with the DeWitts, who had spent a year in Davis, and on the way home I stayed a few days with Mahmood Clor in Rabat, Morocco. Mahmood was another of my students.

IX. HISTORY OF WEED CONTROL RESEARCH AT DAVIS

Dickman: Now, Dr. Crafts, tell me about the development of the weed control research program on the Davis campus.

Crafts: The Botany Department of the University has been known for years for its innovative research on weed control. Beginning with the arrival of Dr. Wilfred W. Robbins in 1922, weed control has received both extension and research effort. After several years of extension work by Robbins and Walter S. Ball of the California State Department of Agriculture, a full-time research position in weed control was established by Dean Claude B. Hutchison and on July 1, 1931, I was hired to establish this work.

At this time while weed control was being carried on in many countries of the world, in California such work involved only a few thousand acres, and the chemicals in use were sodium arsenite, sodium chlorate, carbon bisulfide, sulfuric acid, and KMG, an acid arsenical.

In 1932, Richard N. Raynor registered as a graduate student and he was hired to help on the weed control projects. Raynor had worked in the boron deposits in the Mojave Desert. I was aware that boron, as an impurity in potash fertilizer from Searles Lake, had proved toxic to potato crops. Together we decided to study the herbicidal properties of borax and boron ores. We set up bioassay tests in the greenhouse and soon found that boron in soils was toxic to plants; on January 2, 1934, our first experiments were harvested and we published these results in Hilgardia in 1936.

Meanwhile, I had found a way to make up an acid arsenical solution equivalent to KMG at about one-tenth the cost, and had shown that sodium chlorate could be used for controlling perennial weeds both as a foliar spray and as a soil treatment. In tests on the time required for wild morning glory seedlings to assume the perennial habit, I found that they would sprout from roots twelve days after they appeared above ground.

Dick Raynor went to Humboldt County in 1934 and he established plots at Blocksburg in which he tested all known methods for controlling Klamath weed. Out of this work came the use of borax and boron ores as the most practical method for holding this aggressive weed under control. He returned to Davis in 1936 as a member on the staff of the Botany Department.

Crafts: Bus Ball, Walter's younger brother, and Orville French of the Agricultural Engineering Department collaborated in experiments with sulfuric acid as a selective spray; they published their results in an Experiment Station Bulletin in 1935.

In 1937, Sinox (sodium dinitro ortho cresylate) arrived from France and was sold as a selective spray by the Standard Agricultural Chemicals Company. Warren Westgate had arrived in Davis and he and Raynor established plots in many places in the state using Sinox. They published an Experiment Station Bulletin in 1940 presenting the results of their experiments.

Chet Cleary was another graduate student who helped in the greenhouse experiments. Using the bioassay method, we studied the toxicity of arsenic, borax, and chlorate, and their combinations, in California soils. Results of these experiments were published in 1936 and tests in the field by the plot method with H. D. Bruce, a forester as a collaborator, were published in an Experiment Station Bulletin in 1941.

In 1936, "Weed Control," Agricultural Extension Service Circular 97, was revised and my name was added as an author along with Ball, Madson and Robbins. This circular was the reference used to answer the many questions that appeared in the mail of the Extension Service. This was revised again in 1940.

During these early years, L. W. Kephart of the USDA was engaged full-time to answer letters inquiring about weed control. He also visited the Botany Department each year to check on the project work being carried on.

In the early 1930's, Dr. Robbins wrote letters to Knowles Ryerson, who was Secretary of Agriculture, suggesting that the USDA should recognize weed control as an important technology and carry on experimental work in this area. He never received a satisfactory answer, and it wasn't until a group of Midwestern farmers met and formed a committee which went to Washington and sat on the doorstep of Congress demanding weed control research that the USDA set up work on weed control. This project, organized under six projects, was put into operation in 1936: five of the projects involved cultural methods and were located in the wheat belt under Dr. S. C. Salmon, an agronomist; we at Davis had one project on chemical weed control.

Dr. R. S. Rosenfels came to Davis from Hoagland's laboratory in Berkeley and studied arsenic toxicity and arsenic fixation in soils. Results of his study in eighty

Crafts: California soils were published in Hilgardia in 1939 along with a paper on arsenic fixation.

I published results of toxicity studies in eighty California soils in Hilgardia in January, 1939. I reported studies on the relation of nutrients to toxicity of arsenic, borax, and chlorate in soils in the Journal of Agricultural Research in May, 1939.

Rosenfels and I published on chlorate distribution and the effect of nitrate concentration on chlorate toxicity in soils in Hilgardia in 1941. This work proved that the actions of nitrate and chlorate were antagonistic in soils and it explained many failures of chlorate to control deep-rooted perennial weeds--if the soil was high in nitrate, the treatment was not effective and dosage had to be adjusted to nitrate status of a soil.

In 1942, Robbins, Raynor, and I published Weed Control, A Textbook and Manual. This was the first college-level textbook on weed control. It was published by McGraw-Hill Book Company of New York and proved to be very popular.

Westgate took a position with the Standard Agricultural Chemical Company and he sold Sinox throughout the Western states. He later became the agent for Monarch Nozzles, and these proved excellent, not only for weed control, but for paint spraying, oil furnaces and many other uses.

Raynor served as extension man for weed control in many areas. In 1944, he published with me on experiments in chemical weed control of onions. At this time, World War II was on and the Signal Corps had taken over the campus. Weed control research was intensified.

Raynor, who had been screening dinitro compounds for the Dow Chemical Company left the University to work as a field man for Dow. He left a whole series of dinitro compounds, and I continued the screening. I soon found that dinitro secondary butylphenolwas twice as toxic as the cresol compound in Sinox and very soon Dow and Standard both put out selective formulations based on this latter compound. An Oregon farmer, in order to save labor applied Sinox mixed with ammonium sulfate fertilizer and found the toxicity of the Sinox doubled. Experimentation soon proved that any acid salt, or in fact acid, added to the Sinox would increase toxicity. This was rapidly adopted by spray operators and became known as activation. Reiber of the Chemistry Department and I experimented on this phenomenon and published on it in 1945 in Hilgardia.

During the War, a spray operator in the Salinas Valley found that by spraying young carrots with stove oil he could kill all of the weeds without injury to the carrots.

This induced Reiber and me to study oil toxicity to plants and it soon proved that aromatic oil fractions were toxic. By mixing ten percent of an aromatic fraction of proper weight with ninety percent light aliphatic oil, the selective effect displayed by stove oil could be replicated. We continued our studies using many oil fractions supplied by oil companies and published our results in Hilgardia in 1948. The oil companies soon responded by providing oils for weeding carrots, oils for flax, and aromatic fractions of high toxicity for use on roadsides, freight and lumberyards, and many other industrial uses.

Crafts: When it proved that dinitro-sec-butylphenol was so toxic I tried the basic oil-soluble compound as a fortifier for oils and the Sinox and Dow general formulations were manufactured. These were so toxic that using a surfactant, they could be extended with water, and the fortified oil emulsion sprays came into use.

Pentachlorophenol was among the compounds given to Raynor by Dow to screen. I tried dissolving this in aromatic oil and found that it could be substituted for the dinitro-sec-butylphenol in the fortified oil emulsion formula.

As chemical weed control expanded, use of carbon disulfide to kill deep-rooted perennial weeds by soil fumigation became more popular and the Wheeler Reynolds and Stauffer Chemical company offered Dr. Robbins support for research on methods for using this material more effectively. Robbins hired Robert Hagan and H. A. Hanneson to work on this problem. Working together, they built apparatus to study the diffusion of CS_2 vapor through soils. They found that diffusion proceeded most rapidly in dry soil; that it occurred but more slowly in moist soils and was completely inhibited in saturated soils. Hanneson, Raynor and I published on this work in 1945 in Bulletin 693 of the California Agricultural Experiment Station. This became a standard reference when DD and other volatile organic compounds became so popular in treating soils for nematodes and other soil pests.

The plant hormone 2,4-D discovered by Marth and Mitchell of the Boyce-Thompson Institute was tested for herbicidal properties by E. J. Kraus of the Botany Department of Chicago University. When he found that he could kill plants with low dosages of this compound, he responded to an appeal from President Roosevelt to come to the aid of the nation in World War II. He went to Beltsville, Maryland, where there were facilities for agricultural research and started working in greenhouse and field experiments. He was successful in killing not only annual weeds, but deep-rooted perennials as well.

Dickman: What were the results of this work?

Crafts: Well, R. D. Jones of the Standard Agricultural Chemical Company, manufacturers of plant hormones (Rootone, Fruitone, etc.) wondered why the men at Beltsville had ordered large amounts of 2,4-D and he went and visited the station. When he saw the plots, he went back and applied for a patent on 2,4-D and was granted it. Standard started manufacturing Weedone (2,4-D in carbo wax) for weed control of perennial weeds. A sample was sent to Davis late in the autumn of 1944. I applied it to bindweed plots but it was past the best season and results were not impressive.

The results of Kraus' work were reported by Hamner and Tukey in 1939, and by 1945, people were trying 2,4-D on many weed situations. Soon it became evident that at dosages of one to two pounds per acre many weeds were killed, particularly mustards in cereal crops. Since it proved possible to kill roots of perennial weeds by foliar sprays, it seemed that 2,4-D was translocated in plants and so volumes of spray from 50 to 100 gallons per acre used with sulfuric acid and Sinox were not necessary.

In 1946, an engineer from the Midwest came to Davis with a sprayer that would deliver any volume from 100 gallons per acre to five gallons per acre. Providing the dosage was constant, the five gallon volume was as effective as 100 gallons, the esters of 2,4-D were applied in as little as one gallon per acre and required dosages ran from four ounces to one pound per acre depending upon weed species and growth conditions.

Applying the principle of activation, it soon proved that the most efficient use of 2,4-D would require the ester forms or the straight 2,4-D acid. If a water soluble form was needed the ammonium or the amine salts would be best. At one of the meetings of the California Weed Conference, I explained that the micronized acid in oil should prove effective and American Chemical Paint (Amchem), successors to Standard Agricultural Chemical Company, put out a product containing the micronized 2,4-D in a bland oil that proved superior on brush and woody species. They later put out a solubilized formula coded 638 which is still being used.

Injury to certain sensitive plants from 2,4-D soon became apparent and was found to result from misapplication, to spray drift, and to volatilization of the esters. Grapes in the Lodi region, tomatoes near Woodland, peas near Davis and cotton in the San Joaquin Valley were suffering and soon there were many law suits in the courts over crop injury. Realizing the serious nature of these events, I wrote a paper "The 2,4-D weedkillers: A Warning," which Walt Ball had published in the Bulletin of the California State Department of Agriculture. This came out in 1946.

Crafts: Meanwhile, William A. Harvey, a weed control specialist from Prosser, Washington, came to Davis ostensibly to obtain a Ph.D. degree. He immediately took over the spray demonstration work and Dr. Robbins assigned him extension jobs. He went to St. Louis and worked for two years for Monsanto Chemical Company which was experimenting with herbicides. After two more years he returned and took over an appointment as a weed control specialist in the Botany Department, a position Robbins was able to obtain because of the expanding interest in weed control technology.

During these years a new technique, preemergence weed control developed, first involving use of diesel oil on onion crops to kill seedling weeds that emerged before the onion seedlings. This practice soon spread to other crops. From greenhouse experimentation it soon became evident that there was a hazard involved where Sinox was being substituted for the oil. As long as the topsoil remained dry the crop was safe, but if there were rainfall after spray application and before the crop seedlings pushed through, these would be injured if a water-soluble toxicant, such as Sinox or pentachlorophenol had been used. Raynor and I had warned about this back in 1944 in our paper on weed control in onions but few people saw this. Even Dr. Robbins got caught in this trap when he advised using the fortified oil emulsion as a preemergence treatment on sugar beets. Some growers who experienced a light rain after this treatment suffered loss of a stand of beets. And when 2,4-D was recommended as a preemergence treatment in corn, the same sort of loss was experienced. I voiced a warning against this in 1948 in a paper "Weed Control: Results of Soil Treatment versus Contact Sprays in Corn and Cane," Agricultural Chemicals, May, 1948.

Dickman: Was this about the time you were in Puerto Rico?

Crafts: I was in Puerto Rico in 1947 where I helped in the efforts to kill weeds in sugar cane. Van Overbeek and Velez had introduced 2,4-D in 1945 and had marked success in controlling *Commelina* on the plantations, but as soon as shading by this weed was removed, weedy grasses (crabgrass, goosegrass, and Bermuda grass) took over. I had just perfected the fortified oil emulsion contact spray, and so introduced this weedkiller. Along with Aurelio Emanuelli, a young Puerto Rican agronomist, I put on demonstrations on all of the large plantations on the island.

Crafts: This worked out fine and was largely used until the urea and triazine preemergence materials were introduced.

One unexpected result occurred from these experiments. Often farmers, in order to save one operation, will mix two sprays. It is customary however to recommend not mixing a contact spray with a translocated material because the contact spray kills the leaves and knocks out the mechanism responsible for translocation. The fortified oil emulsion kills grasses and the leaves of *Commelina* but buds in the nodes are protected by the leaf bases and these sprout and reinfest the land. By including a pound of 2,4-D in 50 to 100 gallons of the contact spray, the leaves are killed and the 2,4-D is translocated to the meristematic buds and everything succumbs. This is a case where trials are better than theory.

At the end of World War II many veterans came to Davis to obtain a practical education in agriculture. One of the first of these was Boysie E. Day. Boysie had been in the Army and had advanced from Lieutenant to Lieutenant Colonel in the Infantry. He arrived in Davis in 1946 and was a teaching assistant in Botany in 1949 to 1950. He received his Ph.D. degree in June of 1950: his research involved a study of absorption and translocation of 2,4-D by bean plants. Using the classical bean bend, he found that 2,4-D is absorbed and reaches the phloem in about one hour where it immediately assumes a velocity of from 10 to 100 cm per hour. Boysie concluded that 2,4-D moves with assimilates in the phloem by mass flow, a fact that we later confirmed with C^{14} labelled 2,4-D.

While I was in Puerto Rico, I met Dr. Oliver A. Leonard at the Experiment Station at Mayaguez. Back in Davis, I found that there was interest in getting a man to work on control of woody plants. Dr. Sharp, head of the California Agricultural Experiment Station had purchased some range land in the neighborhood of Sonora and when he started a cattle operation he found that a large portion of this land was covered with manzanita, madrone, live oak and brush of various kinds. When Dr. Robbins approached Sharp with the suggestion of appointing a man to work on woody plant control, he met a sympathetic ear and soon such a position was made available. When Dr. Robbins told me of this situation, I immediately suggested the name of Dr. Leonard.

Oliver was working on translocation in cotton and on weed control in the Mississippi Agricultural Experiment Station. When contacted about the position, he accepted and moved to Davis in the Spring of 1950. He attacked the woody plant problem with characteristic energy, putting out hundreds of plots in the field. Brush control was a popular technology, and thousands of acres of range land were

Crafts: being converted to grassland by bulldozing, and controlled burning. A continuing problem was the resprouting of stumps and the growth of seedling brush and tree species on these burned-over ranges. Oliver worked with the Agronomy staff and members of the State Department of Forestry and made a name for himself because of his careful scientific approach to problems.

About this time Dr. Sharp suggested to me that we prepare an application for funds from the Atomic Energy Commission to conduct work on herbicides. The application received favorable action and on July 1, 1951, we started working on obtaining and using C^{14} labelled herbicides. Dr. Leonard, Charles McCarthy (a research assistant), Douglas Steward (a laboratory technician), and I were the first workers and our initial problems involved repeating the earlier work we had been doing on absorption and translocation of herbicides using labelled compounds.

We started by treating bean plants with C^{14} 2,4-D and killing them with dry ice, thawing, drying and placing them on X-ray film. We were having an artifact: water in the tissues, upon thawing was moving along hydrostatic gradients to drying surfaces and carrying the labelled tracer with it.

When interpretation of our early autographs revealed this artifact, we decided to try freeze-drying. We had a steel chamber constructed, obtained a vacuum pump, and arranged to hold the chamber attached to the vacuum pump within a refrigerator held below zero degrees Centigrade. This solved our problem and we continued to explore the uptake and distribution of labelled herbicides using samples which we obtained from agencies handling labelled compounds and herbicide manufacturers.

Results of this work are amply described in our publications including our final report, "The Autoradiography of Plant Materials," describing our methods and illustrating results of typical experiments. This was published by the California Agricultural Experiment Station Extension Service as Manual 35 which, being subsidized by the experiment station, sold for $1.75. It soon became the standard reference for work with labelled compounds and our methods were adopted in many laboratories across the United States and around the world. It was authored by me and Shogo Yamaguchi, an assistant research botanist in the Davis Botany Department.

Dickman: Who were some of the graduate students in the weed control program during these years?

Crafts: Our program of weed control research at Davis became very popular and the following graduate students received Ph.D. degrees between 1950 and 1963: Boysie Eugene Day (1950), Robert Eugene Wilkinson (1956), Otto Anderson (1957), Charles William Coggins, Jr. (1958), Chester Lattimore Foy (1958), James Edward Pallas (1958), Mahmood Abbas Clor (1959), Thomas Jackson Sheets (1959), George William Mason (1960), and Bernard John Forde (1963).

Many more have worked in the Botany Department weed control program since 1963, but because I retired in 1964, I was not intimately involved in their work. Eight of the above named students worked directly under me and I served on the committees of several more including Wallace Herman Orgell (1954) and Wybo van der Zweep (1954).

* *

In the final report to the Atomic Energy Commission, the following lists appeared:

Graduate Students Trained

	Name	Date	Degree Granted	Home
1.	Wilkinson, R. E.	1956	Ph.D.	USA
2.	Anderson, Otto	1957	Ph.D.	Brazil
3.	Maestri, M.	1957	M.S.	Brazil
4.	Pallas, J. E., Jr.	1958	Ph.D.	USA
5.	Foy, C. L.	1958	Ph.D.	USA
6.	Sheets, T. J.	1959	Ph.D.	USA
7.	Clor, M. A.	1959	Ph.D.	Iraq
8.	Mason, G. W.	1960	Ph.D.	New Zealand
9.	Forde, B. J.	1962	Ph.D.	New Zealand
10.	Pereira, Jose	1962	M.S.	Costa Rica
11.	Neilson, James	1963	Ph.D.	USA
12.	Williams, Gene	1963	Ph.D.	USA
13.	Ongun, Alpaslan	1963	Ph.D.	Turkey
14.	Gad, Ahmed	1963	--	Egypt

Graduate Students Being Trained (Presently)

1.	Pickering, Ed.	USA
2.	Boyd, Fred	USA
3.	Smith, Leon	Australia
4.	Donaldson, Tom	Australia
5.	Rincon, David	Venezuela
6.	Wang, Sheila	Hawaii

Foreign Trainees

	Name	Home
1.	Mr. Ku	Formosa
2.	Mr. Mani	New Delhi, India
3.	Myra Mihajlovic	Yugoslavia
4.	Dr. H. Peterson	Denmark
5.	Dr. W. van der Zweep	Netherlands
6.	Dr. A. S. Islam	U. of Sind, W. Pakistan
7.	Dr. Ronald Wijiwantha	Ceylon
8.	Dr. Charles Greenham	Australia
9.	Dr. Mohamed Radwan	Egypt
10.	Dr. Santos	Brazil
11.	Dr. Bonson	Philippines
12.	Dr. S. L. Kupila	Finland
13.	Dr. Minoru Awada	Hawaii
14.	Dr. Wayne Bingham	Virginia, USA
15.	Dr. Walter Eschrich	Germany
16.	Dr. Fulton Fisher	New Zealand
17.	Dr. Takao Kaneko	Japan

Post Doctoral Tenures

1.	Dr. Fred Slife	Urbana, Illinois
2.	Dr. Joe Koy	Purdue University, Lafayette, Indiana
3.	Dr. Raghubir Prasad	Oxford University

Staff Currently Using Facilities

1. Dr. O. A. Leonard
2. Dr. C. L. Foy
3. Dr. F. M. Ashton
4. Dr. C. R. Stocking
5. Dr. E. M. Gifford, Jr.
6. Dr. R. Weaver (Viticulture Department)
7. Dr. P. Castelfranco
8. Dr. Lloyd Brown (Soils and Plant Nutrition Department)
9. Dr. D. E. Bayer
10. Dr. D. E. Seaman
11. Dr. S. Yamaguchi

As I noted to the Commission, such training proliferates in time and as a result, papers involving the use of radioisotopes in plant research are now coming from several new institutions around the world. A large proportion of the graduate students who train at Davis in the plant science departments use radioisotopes and the facilities of the Botany Department laboratory in some part of their thesis research. (Alden S. Crafts, 1964).

* *

Crafts: Dr. Floyd Ashton came to Davis from the Hawaiian Sugar Planters Association in Hawaii in the mid-fifties. He is a biochemist and has specialized in mode-of-action research. He and I collaborated in a book, Mode of Action of Herbicides, published in 1973 by Wiley-Interscience. He has also carried on plot work in the field specializing in vegetable crop weed control, and is partially responsible for the present status of weed control in tomatoes.

Dr. D. E. Bayer came somewhat later from Oregon. He took on the problem of the toxicity of propanil on prune trees. Propanil is used to control barnyard grass in rice and in parts of the interior valleys of California prunes are grown along the alluvial soils of river banks and rice is planted on adjacent areas of heavier soils. Prunes proved to be highly sensitive to propanil.

More recently Bayer has interested himself in absorption and translocation having studied the role of cuticle in herbicide absorption and the mechanics of penetration and rapid movement with the assimilate stream in the phloem.

Dick Yeo came as a member of the USDA to work on control of aquatic weeds, particularly in lakes and irrigation systems. Don Seaman came from IRRI in the Philippines to work on rice. After a brief stay in Davis, he moved to the Rice Station in Grimes, California, where he continues to work on weed control. Bill Lucas has come as a successor of Herb Currier. His interests are in membrane physiology and he is considering this function in relation to phloem loading and herbicide toxicity.

When one considers the humble beginnings of scientific research in the field of weed control in the early years of the Twentieth Century and compares them with the important place this technology plays in crop production after a mere fifty years, it is apparent that those early efforts have paid off well.

The total sales of herbicides now greatly exceed those of fungicides and insecticides. There are over 200 compounds available for weed killing, many improvements in application machinery, and new technologies such as nontillage, preemergence treatments and a host of new selective materials of remarkable effectiveness. Toxicities of remarkable strength are on the horizon that promise contact weed control at dosages in the ounces.

Dickman: Dr. Crafts, you have had a long and interesting career on the Davis campus, could you list some of your principal accomplishments?

Crafts: Yes, I'll be glad to. And I'll enumerate them. First, we worked out the mode of action in the acid arsenical spray which was the only herbicide for use on perennial weeds at that time. I worked out a practical formula for making up the acid arsenical spray solution. Where KMG the commercial material cost fifty dollars an acre, we could make this material up for about five dollars an acre, the cost of the chemicals.

I worked on the dual role of sodium chlorate as a herbicide. If we sprayed the tops of the plants, they died and it was carried down into the roots to some distance. We found that it was subject to the same rules as the acid arsenical with respect to the depth of penetration. And then if we put the chemical into the soil it would kill by absorption into the roots. So, we worked out a process where we sprayed the plants and then disced them into the soil and irrigated the soil. By this combination of treatments, we got the most effective use of sodium chlorate.

I worked on the comparative toxicity of arsenic, borax, and chlorate in the California soils. I worked on the relation of nutrients to toxicity of arsenic, borax, and chlorate. We found that the toxicity of arsenic was very definitely tied in with the texture and grade of the soil. The toxicity of sodium chlorate depended primarily upon the nitrate content of the soil and the general fertility of the soil. And the toxicity of borax lay somewhere between these two. The "Relation of Nutrients to the Toxicity of Arsenic, Borax and Chlorate in Soils" was published in the Journal of Agricultural Research of the U.S. Department of Agriculture detailing our findings.

Then we worked on the activation of dinitro herbicides. After Sinox came on the market, we found that the activation of the dinitro compounds could be carried out by the use of an acid salt or ammonium sulfate which was used as a fertilizer. This was discovered by an Oregon farmer who applied both ammonium sulfate and Sinox in the same solution and found out that the Sinox was much more toxic. I worked on this with Dr. Reiber; we worked out the chemistry of the situation and there was a paper in Hilgardia covering that.

Now, the toxicity of dinitro butylphenol as a herbicide. The Dow Chemical Company had submitted a lot of samples of dinitro compounds for us to test to see if we could find the most toxic. And among all those, the dinitro secondary butylphenol proved to be the most toxic. And it was not long before the Dow Chemical Company came along with Dow Selective and Dow General and Preemerge, all three of which used dinitro secondary butylphenol as their principal ingredient.

Crafts: We worked on the movement of carbon bisulfide as an herbicide in the soil, particularly the mode of distribution in the soil. And Bob Hagan worked on this for his thesis problem, if I remember right. Then I put out a paper warning of 2,4-D toxicity through the soil. I offered it to Science, but they wouldn't take it, so I offered it to Walter Ball; he had it published in the Bulletin of the State Department of Agriculture, "Toxicity of 2,4-D in the Soil: A Warning."

We worked out the discovery and the formulation of a fortified oil emulsion and contact spray using pentachlorophenol. We worked on the nature of selectivity in the carrot oils and found that ten percent aromatic oil in a light aliphatic oil would do the job. We found out later that Stoddard solvent and a number of others, in addition to stove oil, were selective in carrots. We even worked out one for flax.

We published on the comparative toxicity of 2,4-D in soils; again, it proved that 2,4-D toxicity was related considerably to the textural grade of the soil. It takes much more 2,4-D in the heavy clay soil to render it sterile in order to kill weeds than it does in sandy soil. And 2,4-D was used as a preemergence material in corn for a good many years before some better materials were brought along.

We worked on maleic hydrazide for grass control in cotton and for general weed control on roadsides. We worked out the physical chemistry of herbicidal action. The role of pH, the role of surfactants, the relation to volume, and so forth. We worked on arsenic trioxide, a soil sterilant. It's not being used anymore because of its very high lethality. At the time we cut it out, it was the most successful material on some of the Delta Mendota canal banks which were sterilized with this chemical. We worked, of course, with labelled tracers in weed control research on the absorption, translocation, and on the ultimate fate of herbicides in plants. We worked on the mechanism of translocation of herbicides, and showed that many of them, for instance, 2,4-D and aminotriazole are moved in the phloem along with the assimilates. We worked on the esters of 2,4-D and found that they hydrolized in entering the plants so it was not the ester but it's the ion of 2,4-D which moves in the plant. So it doesn't make much difference which ester you use as far as the 2,4-D is concerned, but it does make quite a bit of difference in the field because the light esters are volatile and will drift and cause damage to nontarget crops.

We worked on the role of humidity in herbicidal action. Mahmood Clor, whom I have mentioned, worked on this for his thesis, showing that if you put plants in a saturated atmosphere, that water will condense on the leaves and that you will get movement from a treated spot through the xylem to many other leaves on the plant. On the other hand, if you leave them in the dry atmosphere, the movement will only be via the phloem down to the roots. We worked on the relation of food and herbicide transport, that is, the fact that phloem-mobile compounds go along with the assimilates in the phloem and in that way we can get them into roots at the time roots are growing.

Crafts: Bidirectional movement of the assimilates is possible in the phloem. I showed that in a paper in Hilgardia. The physiology of phloem transport, mass-flow versus active movement. Physiologists have argued for a hundred years over the mechanism of transport of food materials in plants. And this mass-flow which I mentioned is apparently being finally agreed upon, whereas the active movement which a good many physiologists sponsor has been, we think, shown to be impossible because of the fact that so many toxic compounds are moved right along with food materials.

The significance of the translocation of toxic compounds in the phloem is that the phloem is a living tissue; the sieve tubes are actually alive. But you can get movement fast enough to get 2,4-D clear into the roots of the plants before the phloem is destroyed. This depends upon the very rapid movement of materials in the phloem of up to a hundred centimeters an hour. A hundred centimeters is a meter, which is more than three feet.

We have stressed the structure-function relations of translocation. The phloem versus the xylem. For instance, many of the preemergence materials we work with now, such as the ureas and triazines, are applied through the soil and carried only in the xylem. They do not enter the phloem. On the other hand, a good many of the materials will work into the phloem and some, like maleic hydrazide, will move in both the phloem and the xylem. This information has enabled us to make specific recommendations on dosage relations, for application methods, and particularly for time of use of different herbicides as related to physiological status of the weeds. There is no use applying a phloem-mobile toxicant to kill the roots of a perennial weed, when food movement is principally from foliage to flowers, fruits, or seeds.

The mode of action of herbicides has been greatly illuminated by such studies which are aimed at a physiological explanation of the various ways in which such chemicals affect plants. The book The Mode of Action of Herbicides is in its second edition, due to appear in April, 1981. This work, by Floyd Ashton and me, owes much to the continued emphasis, by weed control workers in the Botany Department at Davis, that use of herbicides is the application of the principles of plant physiology and plant biochemistry to weed destruction.

Alden and Alice at retirement dinner,
Sacramento, April, 1964

X. RETIREMENT AND WORLD TRAVEL

Crafts: On May 1, 1964, Alice and I went from San Francisco to Vancouver, and then on to Edmonton to visit with Helen and Charlie Hedges. Charlie was teaching in the university. We toured Banff, Lake Louise, and Jasper National Forest. And then we took a night flight from Edmonton to Amsterdam, and arriving we saw beautiful tulip fields in full bloom. From then on to Copenhagen. We picked up a Volvo car which we had arranged to purchase and visited the Petersens at Lyngby. Petersens had been at Davis and then they had visited with me at Oxford. They were very good friends. We saw and explored the Hillerød Castle on May 10, 1946. And then we drove on north to Lillihammer, Norway, saw the folk museum and drove back to Oslo. On May 17, Miss Bjerlicke took us to see the parade of the school children at the palace, who had come to visit their king. It was a huge parade with many of the people in the traditional costumes. Following this parade, we drove to the docks and loaded the Volvo onto a ferry for Fredrickshaven, Germany.

From Germany we drove on through Holland where we visited again with Wybo van der Zweep. He was doing weed control research at the experiment station. It's the first time that I had seen nontillage experiments with paraquat. Since then, this practice has spread around the world becoming extremely important.

We saw Emilio Levy at Arnhem, which is near Amsterdam. He was a former student of mine. On May 24, we went on through Belgium to Calais and Dover and reaching England, we visited the Wains at Staple Farm in Hastingleigh. We looked over the Canterbury Cathedral. We saw Ralph and Elsie Stocking at the Rothamsted Experiment Station. And on May 28, spent the day at the Chelsea Flower Show with the Stockings.

We went from London to Oxford and Begbroke Hill where the principal weed control research for the whole British country is being conducted. At Evinlode Road in Stonefield we spent two days with the Woodfords. Ken Woodford was director at the Begbroke Hill Station. Next we drove to Stonehenge, on to Salisbury and westward through Cornwall, St. Austell, and Pentawan Beach to Mevagissey where we stayed for a few days. From Mevagissey we passed through Lands' End to St. Ives and Wadebridge, Longhope up to Bangor, Wales, where we visited with John Harper, the young fellow whom I'd met at Oxford and who since then had spent a year in Davis with us. He is an ecologist.

Returning to Oxford, we enjoyed the Cotswolds again. Accompanying Ken Woodford we visited an agricultural show at Stoneleigh which was visited by the Queen; great excitement. In July, we attended the boat races at Henley where the Russians won the main event. Most of the Harvard crew of 1914 who had won this race at that time were present, fifty years after their race and they rowed the course and were honored by the Queen Mother.

After another visit to Begbroke Hill and a call to John Friar's home at Sandair, we attended a horticulturist meeting in East Malling. Returning again to Oxford, we attended the Sunday evening service at Coventry Cathedral and proceeded north through the lake district and drove on to Edinburgh where the International Botanical Congress was meeting in 1964.

I served as chairman of one of the sessions and reported on our work on translocation by autoradiography. We attended the Edinburgh Music Festival; enjoyed the Military Tatoo; and then started south. On August 21, we stayed overnight in the Royal Oak Motel near Dover and then next day took the boat and crossed to Calais and started south again, touring France, Spain, Portugal, and then we returned to Spain near Gibraltar. We stayed at a motel within a very short distance of the Rock of Gilbraltar. Then we drove on around the Mediterranean to Barcelona, Spain, where I visited a Geigy agency doing weed control on artichokes and cotton. Leaving Barcelona we reentered Southern France where they were harvesting grapes. We traversed the Gorge of the Tarn, and on to Monaco. Following the changing of the guard at Grace's Palace, we proceeded on to Laiguellia in Italy where we visited with the Eschriches of Bonn, Germany, translocation workers who later visited us in Davis. On the following day, we drove into the Dolomites and on over to Geneva where Emilio Levy was vacationing with his family. He worked for the European Atomic Energy Commission.

On September 21, we drove through Interlaken to Grindelwald and here we stayed a few days in a motel adjoining a ski lift which we rode up above the snowline. Leaving Grindelwald, we drove through the Arlesburg Pass on to Innsbruck and after an overnight, proceeded to Vienna. We stayed a few days in Vienna enjoying the beautiful tourist attractions of this place, and then went to see the castle at Neuschwannstein. Then back through Switzerland to Darmstadt in Germany visiting the Zieglers, friends of ours who were working on translocation. From Darmstadt we drove to Copenhagen and from there on to Gottenberg where we turned the Volvo in at the factory for shipment to Los Angeles. It became my son's family car when it arrived there. From Copenhagen we flew to Rome. In Italy, we visited Florence and Naples.

Crafts: On September 15, we flew from Rome to Athens. In Greece we took a cruise ship, the Stella Solaris, for the Grecian island cruise, where we saw all the usual tourist attractions. We stayed at the Hotel Aster and took trips to Delphi, Corinth, Tripolis, Olympia, and during the Christmas vacation we flew to Tripolis in Libya where Mahmood Clor and his family were living and he was teaching at an agricultural school.

On the 28th of December we flew to Beirut and stayed with Tino Rebeiz another graduate student. From there we visited Balbeck, the Cedars of Lebanon, and Biblos. On the 14th of January we flew to Jerusalem in Jordan to the International Hotel. We took an Arab guide and walked the fourteen steps of the cross. I found out a lot about Arab guides on this experience, because he had an uncle who had a store full of tourist gadgets. We would go about two or three steps on this tour to the cross and then we'd end up in his uncle's store. We explained that we didn't want to buy anything, but that didn't help. I think we saw that store at least four times before we got to the end of the tour of the cross.

We went to Bethlehem where we saw the Palestinian refugee camps and the black goat ranges. We can understand some of the difficulties that they're having now with Palestinians when we look back on how those people were housed.

On January 21, we took our suitcases and walked through the Mandelbaum Gate. In Israel we were met by Dr. Tadmor who had received his doctorate degree in agronomy in Davis and who worked in one of our rooms in the Botany Department. Also, I saw Nora Reinholt, whom I had met in 1957 in Oxford. She worked in the adjoining laboratory to me in Blackman's laboratory. I gave lectures before her classes and she took us to see the U.N. buffer zone, the city divided.

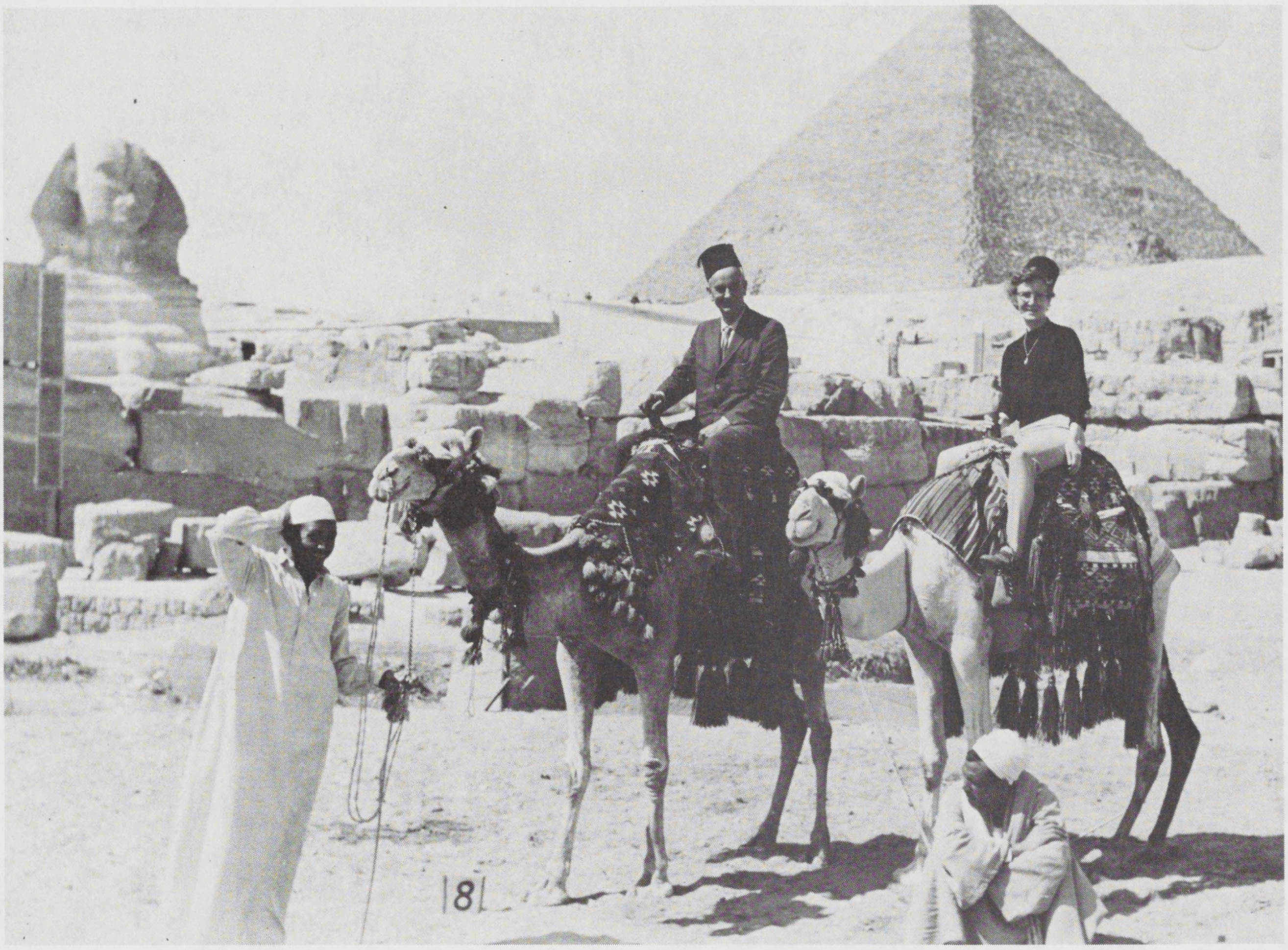
Naphtali Tadmor, the student who had been in agronomy, took us to see the hospital of the Hadassah medical relief and the twelve Chagall windows which are famous tourist attractions. We visited a kibbutz; next day we saw the university buildings and visited Rehovat where the Wiseman Institute is located. Here I was scheduled to give some lectures and when I finished lecturing, about four or five Israeli students came up to shake hands with me; they had been in my classes in Davis.

On January 31 we drove to Eilat which is at the south end of Israel. We stayed at the Queen of Sheba Hotel and one evening we were invited to a home in Eilat. In this home we took a circular staircase down about twenty-five or thirty feet to a room which was completely furnished and perfectly warm. Two Israeli boys with guitars sang us some songs. Leaving Eilat we flew by a small plane to Haifa at a height of a few thousand feet so that we could see the desert of Israel beneath us. When we got to Haifa, we had a barbeque on Mt. Carmel with some friends. I gave lectures and saw herbicide work, experimental and practical. We were under the guidance of Mrs. Ramon who was in charge of visitors for the agriculture of Israel. We saw Mt. Herman from the Hula Valley. And stayed in a kibbutz near the Lebanon border so we could contrast Lebanon and Israel. On the Lebanon side there were black goats in the pasture and practically no grass; on the Israeli side there was green grass and the animals had plenty to eat. We visited a forestry nursery where immigrant women were working transplanting trees from rows in the field into gallon cans for planting in the forests. We returned to Tel Aviv, flew via Air Israel to Cypress, deplaned and changed to an Egyptian plane. Israel and Egypt were officially at war at that time so we couldn't go to Egypt in an Israeli plane.

In Cairo we stayed at the Hotel Cleopatra but after the fourth day we had to move because an important European delegation was coming in. We found another hotel nearby that was considerably cheaper and just as satisfactory.

In Egypt we went to Memphis; we saw the Alabaster Sphinx, the Sakkarah Step Pyramid, and then back to Cairo. We saw primitive farming methods along the way. In one place we saw a young fellow standing on the bank of an irrigation ditch. He had a bucket in his hand tied to a long pole across some cross bars with a weight on the other end. He would dip the bucket into this irrigation ditch, lift it up about three feet, and pour it into another ditch. He was getting the water up onto checks that could not be irrigated by gravity flow.

We visited the Kahn El Kalili market and the Cairo Museum. We saw the King Tut artifacts and this is really something worth seeing. At the Pyramids we rode camels and saw the Sphinx and the light and sound show. We went through the market at Giza, crowded with animals of all sorts and people buying their groceries and supplies. At Barrage City there was a dairy demonstration where there was a modern dairy which had been installed by the United States Government to demonstrate to the Egyptians how a dairy should be run. We took a trip to Luxor and Karnak City. We saw the tomb of the nobles and across the Nile the tombs of King Tut and the Valley of the Queens. Gene and Frances Stafford were visiting, working out of Cairo at that time. I had met her at Beirut by chance in a



Alden and Alice at the Great Pyramid, Giza,
March 3, 1965

market and had arranged to visit them when we got to Cairo. We looked them up and were invited to a party at their house with the Flockers from our Vegetable Crops Department present. They were expecting on the next day that Paul and Dorothy Knowles would be in Cairo; they were travelling through the country in a microbus.

Crafts: On March 20, we boarded the P & O vessel, Oriana, at Port Said. We went through the Suez Canal to Aden and Colombo and Ceylon where we got off and went up to Kandy, had a barbeque picnic, and saw the beautiful arboretum. On the way back from Kandy we saw an elephant being bathed in a little stream. The boys were brushing him off with brushes.

We went on to Perth where Jack Lonneragan, whom I had known in Berkeley, met us and took us to his home where we stayed for several days. I gave lectures at the university and Jack and his wife took us out to the Wooroloo area where the Baker Hill experiment station of CSIRO was in operation. We saw brush removal and became acquainted with the agricultural technology of Western Australia. This whole country is dry; of course, in the center it's all desert, but along the west coast they have fairly good rainfalls such as we have in Davis. And by removing the brush and treating with phosphorus, they could grow subterranean clover. This of course has nodules on its roots and collects nitrogen and after they have grazed this off for a few years with sheep, they can plow it and sow wheat. In the regions where there are sufficient rains, they get very good production of wheat. We saw large elevators in that part of the country to hold the wheat after it had been harvested.

On April 16 we flew from Perth to Adelaide where I was met by Dr. R. N. Robertson a rather famous plant physiologist. At the university I gave lectures again and we toured the fruit growing country and the pastures. We visited a kangaroo farm and saw kangaroos and black swans. We saw a plaque to Amos Howard who had discovered subterranean clover which was the key to this whole modern agricultural technology. We saw brush clearing. We saw skeleton weed which I had never seen before, and at the Adelaide Botanical Garden we took pictures of beautiful dahlias which I still have.

We flew on to Melbourne where we were met by Bill Parsons who had spent a year with us in the Botany Department at Davis. After a day or two in his house, we moved to a motel right in the center of Melbourne and Bill saw to it that we had lots of travel around that region. We saw the surrounding country where weed control experiments were being carried on. They had just started working with the logrithmic sprayer. We went down to Gippsland and saw red gum six- and eight-feet in diameter; tremendous, large trees. We saw skeleton weed plots where trichlorbenzoic acid at twelve pounds per acre was the recommended treatment. We went to Ballarat where the welcome nugget was discovered and saw the King George Hotel which is a very famous tourist attraction.

On May 12 we flew to Hobart, Tasmania, and did the usual tour. We went to Port Arthur prison which was a noted example of man's inhumanity to man, where the people were put up in solitary confinement and in those days many of the people in that prison had been arrested in London for very minor offenses. For instance, if a girl dropped a handkerchief, she could be arrested for advertising and was put on the boat to go to Tasmania to the Port Arthur Prison.

Back in Melbourne, Parsons drove us to Phillip Island where we saw koala bears in the trees. They had a summer home down on the beach at Phillip Island and there we went in the evening and saw the fairy penguins come marching out of the water going up into their nests. On May 20 we drove to Wagga Wagga where the Cuthbertsons were carrying on weed control experimentation with chemicals. I was very pleased with the work that Cuthbertson was doing as it paralleled much of the work that we were doing at Davis.

From Wagga Wagga we went on to Canberra and the Charles Greenhams met us there. Charles and his wife, Jean, had spent a year in Davis about two years before we were there and we had become very good friends. Charles arranged for us to live in student rooms in the university because it was vacation time. And I gave my usual lectures and went out and saw the forests, particularly the Monterey pines. It's an interesting thing. The Monterey pines in Monterey are very beautiful, picturesque trees, but they certainly couldn't make any lumber of them because they're crooked and straggley. In Australia and New Zealand, they grow perfectly straight and they will outgrow even the best of our other pine trees. There are literally millions of acres, or at least thousands of acres, of Monterey pine trees that have been planted in Australia and New Zealand.

We saw the University of Canberra's Ceres phytotron. We saw Canberra Lake, the artificial lake that was created by building a dam; it surrounds the city and improves the climate there very much. We had a visit to Bateman's Bay down on the beach and saw the beautiful country.

On June 15 we took the Snowy Mountain tour. On a bus we drove up through the mountains and were amazed at the high technology. We drove into the center of the mountain in a tunnel and saw a big generator being powered by water which came straight down from a lake which was directly above. The technology of water reclamation and water use in Australia is equal to that of ours in California.

On June 24 we flew to Sydney where I was met by Nelson Johnson a friend who had visited us in Davis. He was with the Imperial Chemical Industries Limited of London and they had an agency there to sell herbicides. I gave my lectures to the staff of the station and we had a trip to a koala bear sanctuary where Alice enjoyed the bears very much. Then we went with Jock Robertson, an Australian who had been consigned by the agriculture people to take us out into the country. We took a trip to the Minnel Ranch where we saw lime bush and drought-fed sheep. Sheep were being fed corn and fodder and also they explained that they could cut the branches off these lime bush trees, spray them with urea and molasses and the sheep would be maintained until they had more rain. That is, through the drought periods. In fact, there's a publication from the university there on the edible brush species of Australia. We saw thousands of acres of range trees and pulled forest.

Finally, we went on to Brisbane where we visited the Lone Pine Koala Sanctuary and again enjoyed the little bears. There they were trained to sit on the backs of dogs and ride. We flew to Gladstone and went on by boat out to the Heron Island Resort, which is the south end of the Great Barrier Reef. We enjoyed this barrier reef country very much because we could wade right out and see all of the beautiful coral and algae growing within two and three feet of water.

On July 16 we took Precongress tour buses to the Raft Ranch and went out into the cactus country. Now, I don't know how many people realize it, but at one time there were sixty million acres of land in Australia completely covered with cactus to the place where animals could not penetrate them. This is an area the size of the state of Oregon. They set up a cactus control program, went out and searched around the world for pests and brought back a moth from South America which proved capable of completely destroying the cactus. The moths lay eggs in the cladodes of the cactus. Those eggs hatch out into grubs which eat the whole center out of these structures. We saw where there were a few cactus plants growing but they were completely parasitized by these cactoblastis insects.

We took a Precongress tour to the Raft Ranch and across the Darling Downs and on to Toowoomba on July 19 and 20 where we attended the Australian Weed Conference. I gave my usual report on autoradiographic techniques and on July 25, we flew to Auckland, New Zealand, where the Ivon Walkins Chemical Company entertained us. I knew Dan Watkins and George Mason who worked with him and they saw to it that we were highly entertained in New Zealand. We went out to the Kauri Forest; we went to Hamilton where we took part in the weed conference, giving reports on our work; we toured New Zealand; and saw plots of the Ivon Walkins Dow Company. We flew to the south island to Christchurch where I lectured at the university. We were supposed to fly over Mt. Cook, but it was stormy and we failed to do that. Returning to Auckland, we went via Nandi, Fiji to Hawaii and on home on August 30, 1965.

Crafts: I was hired by the Botany Department part-time to work with the graduate students and this lasted until Governor Reagan was elected and he cut the University budget and I lost the job.

Shogo and I had prepared a final report to the Atomic Energy Commission on our work on herbicides. We suggessted that they publish it but they refused to do it, saying that was not their business. So Shogo and I then worked up our final report to a paper which we called "The Autoradiography of Plant Materials." When I showed this to Maurice Peterson who was then director of the Agricultural Experiment Station, he immediately recommended that it be published in the manual series of the extension service down in Berkeley. I took it down and in June, 1964, it was published and a copy reached me while we were touring on our trip; we were in Oxford at the time. I took it along and showed it to people all the rest of the way around. It was out of print in 1971 and is no longer available. There were five thousand copies printed.

In 1965, in Vienna, I gave a paper on the use of isotopes in weed research. I had become very familiar with a group of slides which I'd used during the world tour, from which I gave seventy-five different lectures. One series of these slides showed translocation of 2,4-D, monuron, aminotriazole, and maleic hydrazide in soybean seedlings. There were noted contrasts here. The 2,4-D showed limited phloem transport, the monuron showed only xylem transport, the aminotriazole showed unlimited phloem transport and maleic hydrazide showed phloem transport plus leakage into the xylem so that it circulated in the plant. There were two phenomena here that were important. One was the discrimination. When those molecules were applied to the sides of the stem and penetrated, then went into the plant, some of them were moved into the phloem, others bypassed the phloem and went on in and moved in the xylem. It showed that the cells in these stems could discriminate between different molecules. The second thing it showed was the possibility of bidirectional movement in the phloem, and in

Crafts: January, 1967, I put out a Hilgardia on bidirectional movement. Bidirectional movement had been cited as one reason for doubting the mass-flow mechanism but I showed that it could be explained on the basis of mass flow.

In 1966, I reported at the Symposium of the New York Academy of Science on absorption and translocation of labelled tracers. And in 1967, Ted Kozlowski, a very good friend of mine who does editing for the Academic Press, one of the big publishers, asked me to write papers for a two volume work that he was putting out on water deficits in plant growth. For the first of these volumes I wrote a paper called "Water Structure and Water in the Plant Body." In the second one, "Water Deficits and Physiological Processes." These papers became very popular and the thing I noticed particularly was that the fifty reprints that I received lasted about a week.

In 1969, I had a second world tour. The International Union of Pure and Applied Chemistry was putting on a symposium in Johannesburg, South Africa on chemicals in the human environment. There were also meetings in Tokyo and meetings of the Pacific Science Congress in the Philippines, and so I took this tour to engage in discussions and reports at a number of meetings. We flew first to Tokyo where I gave a paper before the Atomic Energy Society. Then I flew on to Hokkaido, the north island, where I had been asked to give a report on our autoradiographic technique at Sapporo at the university. When I reached Hokkaido, I was picked up by a young fellow in a car and driven on to Sapporo. But I didn't get to see the man whom I had corresponded with because he was engaged in talking with the students out at the gate of the university. They were about to have some problems with the students rebelling.

I visited the famous botanical gardens in Sapporo and took a lot of pictures. It's a beautiful, beautiful garden and the city of Sapporo itself is very nice.

I flew then on to the Philippines where there was a meeting of the Pacific Science Congress at which I reported. I also gave two papers at the International Rice Research Institute, one on water structure and one on absorption and translocation. We flew from Manila to Thailand, to Bangkok and reported at the university again. I was taken out to see some of the country around Bangkok.

Then on to New Dehli where I reported at the experiment station. Here I saw a very interesting situation. There, I met Mani, a man from New Delhi who had visited Davis and spent several months learning our autographic techniques

Crafts: and all of our chemical weed control methods. He had gone back and established a lot of plots where he showed very good use of herbicides in controlling particularly the weeds in cotton. Now, right next to this was a field of the Agronomy Department with about forty acres of cotton where the cotton plants were about eight inches high and the weeds were about six inches high. You just could see the rows of cotton above the weeds. And they had thirty or forty people out there pulling all of those weeds out by hand. Yet when I got into the headquarters where the director of the station was, I saw that they had very modern equipment for studying the chemistry of cotton. Gas chromatography to determine the oil in the cotton seeds and there was a big institute of agricultural mathematics there where they had calculators for determining probable errors and all of the various things that they needed in modern agricultural research. But when I asked them what they used for a normal cotton plant, they said one of those out in that field. I explained to them that if a cotton plant has competition with weeds, after it gets to be four or six inches high, then it will never make a normal plant. And so, they didn't have a single normal plant to set up as a standard for all of their calculations in the production of their cotton!

We flew from New Delhi via Addis Ababa, to Stellenbosch, South Africa, where I visited with John DeWitt and his family who had just come back from a tour in Davis. They'd been in Davis for a year and I knew him quite well. They took us to Cape Town and the Kirstenbosch Gardens where there are beautiful native plants.

Back in Johannesburg, I took a trip to Kruger National Park and saw all of the animals. At the IUPAC symposium I gave a report, "Pest Control, A New Industrial Revolution," describing preemergence herbicides, nontillage and the technology of the new agricultural revolution.

I gave this same discussion at the University of Stellenbosch and talked on autoradiography in the service of weed control. Since the subject of the symposium was chemicals in the human environment, there were many environmentalists attending. When they questioned the use of pesticides, I wished that Emil Mrak had been there to give them his talk on the subject. I don't think a single one of them had lived on a farm and seen a crop devoured by locusts or smothered by weeds.

One morning while there I awoke, turned on the T.V., and witnessed the first moon landing.

Crafts: From Johannesburg we flew to Rabat, Morocco, and visited with Mahmood Clor again. He had moved from his former station to Rabat, where he was teaching in a school. He took us to Casablanca and then up into the mountains to Meknes, Fez, Imouzer, Infrane, and D'Azroux. We saw a carpet factory with child labor, ten to fifteen-year-old girls running machines. After this visit, I flew back to New York and on to Arlington and saw Helen and her family. This was my second world tour.

In 1970 the FAO held a conference on weed control in Davis. Floyd Ashton and I delivered a paper, "The Role of Basic Research in Weed Control." Since it was clear that the pores in the sieve plates of the phloem are open and that normal assimilate movement in the phloem takes place by mass flow along a turgor gradient, it seemed that a book covering the history of translocation research and the current research particularly with labelled compounds was due. I started review of the literature in 1965 and started writing.

In October, 1967, I wrote McGraw-Hill Book Company, who had published the first three editions of Weed Control, and asked if they would like to have this book. They asked me to submit a prospectus and table of contents. This I did on December 8, 1967. By March 7, 1968, I had mailed in the final chapters. In July, I sent in the illustrations. By November 19, I was promised a contract soon. It was obvious that I was being put off. In January I had a very odd letter explaining that McGraw-Hill couldn't afford to publish my book.

I was in the final stages of complying with the reviewer's requests that had been sent to me by McGraw-Hill when I decided to ask a young man to serve as coauthor. I selected Carl Crisp, a former student working in the U.S. Forest Service Laboratories in Berkeley. Carl was happy to do this and we worked together and we submitted the much improved manuscript to the Freeman Publishing Company in San Francisco. They were glad to publish it. So Phloem Transport in Plants came off the press in May, 1971, and it is still selling today in 1981.

In 1957 I wrote a paper, "The Chemistry and Mode of Action of Herbicides," that proved very popular and in 1961, at the request of Interscience publishers, I expanded it into a small book. This again proved popular and in 1971 Interscience asked me to expand and update it again. Because I had been retired for seven years, I again decided to seek a coauthor. I asked Floyd Ashton to serve as principal author. He accepted and we started working. This book, The Mode of Action of Herbicides, came off the press in January, 1973.

Crafts: In 1972, Alice and I took a trip to visit Marg, her sister who was in Pakistan where her husband, Ray Haskell, was principal of the American School in Islamabad. We started September 1 and visited Tokyo, Hong Kong, Bangkok, and New Delhi. We saw the Taj Mahal by sunlight and by moonlight. We flew to Jaipur, saw the Amber Palace, went on to Udaipur where we stayed at the Lake Palace Hotel which had been highly recommended to us by one of Alice's friends. It was an interesting place entirely surrounded by water. Returning to New Delhi, we headed for Islamabad only to find we needed visas to enter Pakistan from India, since these two countries were still at war. We flew to Kabul in Afghanistan and after some manipulation were able to obtain a visa. Then we flew down over the Khyber Pass which is some of the most beautiful country I've ever seen.

In Islamabad we visited with Marg and Ray, bought some brass and copperware, saw a new dam being built on the Indus River, and then flew home through Karachi, London, and Dulles airport where Helen met us with her newly adopted daughter, Rosemary. We flew to Sacramento and home.

I then started work on the revision of Weed Control. When I had it well along, I wrote McGraw-Hill to find if they would like to publish it. I got a very creepy letter this time in which they turned me down again. I went to the University of California Press in Berkeley and they were happy to take it, so I started work on it.

During this time, we attended the California Weed Conference at Woodlake Inn in January, 1974. I went to Washington for a meeting of the National Research Council Committee on "Arsenic in the Human Environment." I attended several meetings and we finally put out a book on the subject. On January 28, 1974, the Weed Science Society of America met in Las Vegas.

Alice continued to have trouble and by February, her problems were getting more serious. She fell three different times. Twice she became lost and I had to go to campus to bring her home. Then on Saturday, April 6, she fell in our clothes closet in our home and became incoherent. At the Davis Community Hospital, she lived with support in a coma and on April 21, was moved to the Driftwood Convalescent Hospital. She died on Saturday, May 11, from a failed heart. We had a service in the Davis Community Church, and burial in Potter Valley Cemetery, Potter Valley, Mendocino County, the town in which she grew up. Life moves on.

Crafts: Helen and Charlie, who came to the funeral, took me to visit my nephew Arthur Bright, who owns a successful tree growing operation in Plainsburg in Merced County. We came home through the Yosemite Valley, drove to Pillsbury Lake on the Eel River, and then home via Willits visiting with Ethel Berg, Alice's sister. I returned to Washington on the arsenic committee business. And, in August, I hosted two Italian boys with a high school international inter-study group. I had a call from David Williams from Auckland, New Zealand about a case of 2,4-D injury to grapes. I conducted an ecology tour for the inter-study group and we gave them a farewell party at the high school. And so, it was the usual busy work.

Harold and Helen had both urged me, "Pop, don't retire to your couch on the side porch, keep in the mainstream." I asked, "What do you mean--remarry?" "Do you appreciate that there are at least forty eligible widows in Davis." And Harold replied, "Don't worry dad, just let nature take its course."

The John Moyer family came to Davis in the Forties. He was a very excellent mechanic. He had two girls in high school whom I'd seen many times as I walked past the school on my way to work. Alice heard of John and when we had trouble with service on our Mercedes, she had him take care of it. I had gone to their house on Eureka Avenue to get it and if John had not finished it, I was invited in. There were two boys and a girl younger than the high school girls. And I met the mother, Helen. John had a heart attack in 1968 and died. Helen was left with three younger children. She had worked as a technician in food technology for several years and rented rooms to girl students.

On September 18, they had a flotilla meeting of the Mariners in the Davis Community Church and for some reason, that I'll never quite understand, I decided to go to this meeting. I made a cake and went where I met Helen Moyer and Lulu Nelson, in the group standing around talking before the meeting took place. It was a pot luck dinner and I had brought my cake. While we were standing around talking before dinner, Helen Moyer stepped up to me and asked, "Didn't you and Alice used to attend the Friday night movies in Kleiber Hall?" I replied, "Yes." And she said, "Why don't you and I do that some time." And I replied, "Sure."

This was the answer to Harold's suggestion. I made a date to visit Helen on Saturday evening and we had a long talk. I was lonesome and she was too young to give up hope. We dated many times that Fall. Just twenty-three days after the Mariners meeting, we went to Styler's and I bought her a diamond. On Friday, December 6, we were married in Reverend Don Mason's office, with Donna, his wife, as witness. We drove to the Brigadoon Motel in Vacaville for our wedding night and on Saturday, we drove through Napa Valley to Calistoga and through Geyserville, Cloverdale, Ukiah, and Willits, to Fort Bragg and booked at the Seacliff Hotel. We walked on the beach, combed for shells, slept to the roar of the waves and breakfasted at the Thanksgiving Health Food restaurant with forty bags of coffee lining one side. We walked through the Mendocino Botanical Gardens, watched the waves break on the rocks, and returned home via Mendocino City, Albion, Booneville, and Anderson Valley.

We were back in time for a concert by the University concert band in Freeborn Hall. We visited Harold on Monday, December 23. He took us to San Francisco on Tuesday, where we boarded a plane for Miami and the Bahamas. In Nassau we met Helen and Charlie and the kids. They had arranged this trip for us as a honeymoon trip. And we had a fine time with them on the beach. We celebrated our first Christmas together. We bathed, sunned, went into Nassau sightseeing.

I had agreed to attend the Twelfth International Botanical Congress in Leningrad, which was to take place in 1975. During the Spring, I prepared a paper and completed arrangements for a flight on a charter plane. On July 1, we flew to New York and took off at 6:00 P. M. On July 2, we arrived in Helsinki in the morning. We had a tour of the city, lunch at about 1:00 and proceeded to the Russian border. We arrived at 4:00 and by 6:00 were on our way across Russia. Forest, trees, and farms; we were in our hotel by 10:00, had dinner, and retired. The Congress was crowded. There were three thousand people. There were sessions during the days and banquets at night. I chaired a session on plant water deficits. After Leningrad, we visited Moscow, Kiev, and Minsk where we saw a circus. Back home we had our house painted and visited many friends.

1976 was the year of travel for Helen and me. In January, we flew to Lima, Peru to visit Marg and Ray Haskell. We went to Cuzco, Machu Picchu, the famous hidden city of the Incas, and to Picallacta ruins which were originally barracks of the Indians. Then we went on to Quito, Ecuador and Bogota, Colombia. In April we had eleven days in Hawaii. And in May, I

Crafts: flew to Auckland, New Zealand, to look at the situation where grapes in the Montana Vineyard were injured by 2,4-D spray, which had been applied to kill thistles in the neighboring pastures. I flew back from that trip and I knew that there was a court case coming up.

Helen and I flew to Auckland where we started a nineteen day tour including the south island. Back from the tour we visited Bernard and Margo Forde in Palmerston North, and George Mason in New Plymouth. We had three more days at the Bay of Islands. In August we had a green carpet tour of Alaska for twenty-four days.

The solution to the Montana Vineyard situation of 1977 had been very interesting. It never came to a regular court trial because in the early proceedings of the trial, it turned out that the Montana Vineyards claimed they had a fifty percent reduction in yield of their grapes in that year. When the lawyer for the defense looked into the production of wine, he found that the Montana Vineyards had produced and sold just as much wine in that year as they had in previous years. When this became known in the discussions, the Montana Vineyards sued for a settlement out of court as soon as possible. They didn't want people to know that they were making wine out of water!

In 1977, we had only one trip, an autumn color trip across Southern Canada and down the East Coast to Williamsburg, Virginia, and home via the Badlands, Mt. Rushmore, and Butte, Montana.

In 1977, I had my 80th birthday party at the Faculty Club. I had, I think, over a hundred friends there. During these years, we read Centennial by James Mitchener and Roots by Alex Haley. While I read aloud, Helen cut blocks and put together quilts.

In 1978, we had eleven weeks touring England by car, stopping overnights at bed-and-breakfast houses. And three weeks in Nevada, Arizona, Utah and Colorado National Parks. In 1979, we circumnavigated the USA driving from Davis to Key West, Florida, up the East Coast to Montreal and across to Banff, Lake Louise, Jasper National Park, Yellowstone, the Tetons and back to Davis.

In 1979, we had a cruise from Acapulco, Mexico through the Panama Canal to Cartagena, Colombia, Aruba, St. Thomas, to San Juan, Puerto Rico. Here we rented a car and drove to Mayaguez and back, circumnavigating the island. I had spent the year 1947-48 in Puerto

Crafts: Rico and wanted to see what had been going on in the meantime.

Back home we attended the usual meetings, parties and so forth. In November, 1979, Daphne Osborne, an English botanist, whom I'd known well in 1957 and 1958 while I was working with Blackman, came to Davis to deliver the Storer lectures. She stayed in Davis for two weeks, the last four days in our home. On December 1, 1979, we drove to Redwood Valley for the 89th birthday party of Mabel Whitcomb, an old family friend from Potter Valley days. Her husband had been Alice's uncle.

In 1980, we had a three week tour of the People's Republic of China, followed by a week in Japan. We flew to Peking via Tokyo and visited Huhehot, the grasslands, Hangzhow, Shanghai, and Soochow. In Japan, we went to Nikko and back and then past the Kamakura Buddha to Lake Hakone, Nagoya, Togo Bay, Pearl Island, Ilse Shrine, to Kyoto. Having flown home, we enjoyed the Fall Festival of the Faculty Club and the annual meeting of the Golden Society. I joined the Chancellor's Club.

In 1978, at Helen's suggestion, I started writing an autobiography. Harvey and Pam Moyer left Riverside in 1979 and came to Davis. I asked Pam to type it for me. This she did and in 1980, I deposited a copy in my archives in the UCD Library. It is being retyped at the present time (February, 1981) and I am considering offering it for publication. I have some 280 eight-by-ten color enlargements of my favorite slides taken in many parts of the world. I am considering the possibility of using these and making a combination script and picture book of the type that is so popular now.

Old Timers' Club, Boise, Idaho, 1979
(Alden Crafts center of back row)

Alden and Helen Crafts
Great Wall of China, September, 1980

APPENDIX A. A TRIBUTE TO DR. W. W. ROBBINS

Dr. Robbins was born on May 11, 1884, in Mendon, Ohio, the son of a midwestern farmer. He grew up on the farm, an experience which served him well in many ways in later life. For his higher education he went to the University of Colorado where he received his A.B. degree in 1907, his masters degree in 1909. He taught high school in Golden, Colorado from 1907 until 1908, and in the University of Colorado from 1908 until 1911. From 1911 until 1914, he taught at the Colorado Agricultural College at Fort Collins, where he became Head of the Botany Department and took charge of the Colorado Seed Laboratory. He went to the University of Chicago for his Ph.D. degree in 1917, and then became Plant Physiologist and Pathologist for the Great Western Sugar Company from 1919 to 1921. He served as Botanist in the Office of Cereal Investigations Bureau of Plant Industry U.S.D.A., where he had experience in Barberry eradication against wheat smut.

Upon assuming Directorship of the University Farm at Davis, Dr. Claude B. Hutchison recommended the appointment as Head of the newly formed Botany Division, Dr. W. W. Robbins. Robbins had made a name for himself as a teacher, an Extension worker and as a research scientist. Arriving in Davis in 1922, Dr. Robbins immediately initiated a program of teaching and applied research. During his years in Colorado, Robbins published his well-known book, The Botany of Crop Plants, which first appeared in 1917. He had conceived and developed new and revolutionary ideas on classroom teaching. He nurtured the philosophy that botany and agriculture are disciplines with many common interests that could be interrelated in a common curriculum.

Soon Dr. Robbins made contact with Professor Richard M. Holman, who taught plant physiology in the Botany Department in Berkeley. Together, these two wrote the famous Textbook of General Botany, a book that dominated the field of elementary botany teaching for over three decades. In the preface of this book, which appeared in 1924, Holman and Robbins expressed the conviction that both general students and agricultural students should profit more from a broad survey of the field, related wherever possible to agricultural practices and problems, and by the use of economic plants for illustrative material, than from narrowly specialized aspects of botany. The validity of this belief is shown by the immense popularity of their book, the fact that it went through a whole series of revisions, and that most of the texts that have appeared since have adopted, at least in part, this same conviction.

Dr. Robbins was an enthusiastic and inspiring teacher in the classroom, on the lecture platform, and through his publications, and in his teaching he brought purpose into the lives of generations of students. He believed that ultimately all real knowledge should somehow have its impact on the lives of men. He believed in botany as a science and as a discipline, and he believed in agriculture as a way of life. He believed in work and he believed in play; and he had the happy talent of being able to see and inject play into his own work and into the work of others. While teaching with vigor he was able to lighten the labor of the classroom to a point where learning became a pleasure.

Upon arriving in Davis, in addition to his teaching duties, Dr. Robbins initiated research in vegetable crops and in sugar beet production. With Drs. H. A. Jones and H. A. Borthwick he studied production of asparagus, contrasting the crop yields of male and female plants and conducting analyses of the chemical composition of each.

From his Colorado experience Dr. Robbins brought interest in sugar beets. The sugar beet industry in California was struggling, not too successfully, to maintain itself, with the virus disease curly top making serious inroads on yields. Dr. Robbins attacked this problem with characteristic vigor. This disease was carried over and transmitted by leafhoppers, insects that overwintered on native weeds and migrated to the beets as soon as they came up in the spring. By a series of time-of-planting tests, Robbins found that sugar beets could be planted in California in October or November; they would germinate and grow during the relatively mild winters and become large enough by spring to survive and grow well despite the attacks of the leafhoppers and the attendant curly top.

Also it was found that by spraying the Russian thistle plants upon which the leafhoppers overwintered with a phytotoxic oil, the leafhopper population could be greatly reduced. And concomitantly a breeding program to develop curly-top resistant beets was initiated; much of the breeding was carried on by the U.S.D.A.

In the late 1920's Dr. Robbins hired a student, Miss Katherine Esau, to work on his sugar beet project. The daughter of German parents who had been in Russia during the 1917 revolution, Katherine with her parents fled to Germany where she had done her undergraduate college training. The family had migrated to a location near Fresno, and Katherine came to work at Davis. During her first months with Dr. Robbins, Katherine hoed weeds on the sugar-beet plots. She enrolled and started taking advanced courses. And under Dr. Robbins' tutelage, she tackled the problem of the anatomical effects of curly-top virus on the sugar beet plant. She took this as her thesis problem, obtaining her Ph.D. degree in 1931. She since has become a world-famous lady Botanist in the field of Plant Anatomy, having written several books on the subject.

Dr. Robbins developed an interest in weeds and poisonous plants during his early years in Colorado and by 1930 was able to initiate a program of weed research in California that has been a foundation for this important and growing science. He brought Walter Ball from Fort Collins to Sacramento where he entered the program of the California State Department of Agriculture on weed control and seed inspection and regulation. Robbins and Ball traveled the state giving lectures at Farm Bureau meetings on the importance of weed control. They explained the effects of weeds on crop yields, as alternate hosts for plant diseases, as sources of pollen causing allergies and in the case of poisonous plants, on animal production.

This project was so popular that by 1930, Dr. Robbins was able to obtain from Dean Hutchison a position for a full-time man to conduct research on weed control. This was where I entered the picture. I had been born in Fort Collins, Colorado on June 25, 1897. My family moved to California in 1903 and I had my schooling in the Bay Region through one year at U. C. Berkeley in Agriculture. I stopped out in the summer of 1917 and had one year as a farm laborer and seven years in Potter Valley on our family farm. At the suggestion of Dr. Holman, I returned to school in 1925 going to Davis where Dr. Robbins gave me a job in the laboratory washing dishes; on Saturdays I cleaned house for Dr. Robbins, whose wife Louis taught Botany in the Sacramento Junior College. At the end of the year, in the summer of 1926, Dr. Robbins persuaded me to go to Berkeley and prepare for a research career. This I did and when I had completed my final examination for the Ph.D. degree, as a member of my committee he stepped up and asked me if I would accept a position on his staff to conduct full-time research on weed control. I explained that I had accepted a National Research Council post-doctoral fellowship to work for a year with Professor O. F. Curtis of Cornell on a problem of phloem transport in plants. He replied that he would hold the position open until July 1, 1931. This he did and I started my professional career at that time, the first person to hold a full-time position in weed control research.

Dr. Robbins established the first college-level classroom instruction in weed control as a scientific discipline and as senior author of the first two editions of the textbook Weed Control was responsible for the introduction of this subject into many college curricula. By means of Extension lectures and correspondence, he spread his enthusiasm and interest throughout the western states. He was interested in and instrumental, along with Walter Ball, in the formulation of the Western Weed Control Conference, established in 1938. He was also involved in the establishment of the California Weed Conference in 1949.

As a representative of the office of the Foreign Agricultural Relations of the U. S. Department of Agriculture, he gave, in 1948, over eighty lectures and conferences on weed control in agricultural institutions in South America. Robbins was an active and enthusiastic Rotarian having the office of District Governor for some time. He was in demand as an after-dinner speaker. He served as President of the American Society of Sugar Beet Technologists for the years 1949 and 1950, and was appointed a vice-president of the Section of Agronomic Botany of the Seventh International Botanical Congress in Sweden in 1950. During his trip to South America, in recognition of his contribution to South American agriculture, the University of Montevideo conferred upon him an Honorary Degree.

Dr. Robbins' role in the development of weed control as a science was unique. There have been many great teachers of Botany, many effective Rotarians and many distinguished extension personnel. In the 1920's there were well-developed departments of entomology and plant pathology in the agricultural colleges and experiment stations across the land. But weed control as an agricultural technology was virtually unheard of. A few agronomists, a few botanists, and some agricultural chemists had performed simple experiments but one could count on his fingers the numbers of men and the numbers of chemicals involved. But Robbins through experience, through insight, and through intuition knew that weed control as a field of endeavor had promise. And throughout his professional life he continued to stress its importance. He led in initiating a research program in weed control, he instituted the earliest college-level classes in weed control, he was senior author of the first college-level textbook and manual of weed control, and through his personal contacts with agriculture, he preached weed control as an essential part of agricultural technology. It is sad that he was taken before the phenomenal expansion of weed control throughout the 1960's and 1970's. Now, sales of herbicides exceed those of insecticides and fungicides combined. And new, revolutionary technologies such as non-tillage, controlled droplet size of sprays, and use of biological agents such as bacteria and fungi in weed control have basically altered the technology of crop production in many important ways.

Dr. Robbins was concerned with the development of the Davis campus. During his last years, he served on many committees devoted to the welfare of students. In collaboration with Professor T. E. Weier, he wrote a new modern textbook of botany. His leadership and warm personality are ever fresh in the memories of those he taught, and those who worked with him in his agricultural activities.

APPENDIX B. TRIBUTE TO DR. J. P. BENNETT, 1887-1975

Dr. J. P. Bennett was an outstanding plant physiologist and teacher. He supervised the training and research of a large number of graduate students, many of whom have gone on to establish themselves as leaders in their fields.

I became acquainted with Dr. Bennett in the fall of 1926 through his friendship with Dr. P. B. Kennedy with whom I had an assistantship to work on the control of bindweed, an important pest in California. With Dr. Bennett's help I was able to work out the mechanism by which arsenic applied in an acid solution was able to penetrate the leaves of bindweed and move deep into its root system. During the four years that I worked to receive my Ph.D. degree in Berkeley, Dr. Bennett provided me a teaching assistantship in his laboratory course in plant physiology. During the summer vacations I assisted him in his research on chlorosis of pear trees in the Santa Clara Valley. We worked together injecting various iron salts into these trees, finally developing a practical procedure for curing this nutritional disturbance. I also helped him conduct his well-known work on dormancy, carried out in the greenhouse and in field plots on the Gill tract.

Dr. Bennett was interested in plant water relations, the uptake and distribution of mineral nutrients and translocation of assimilates in plants. He was my major professor during my graduate studies from 1928 to 1930. He provided me with work space in his laboratory, greenhouse space, and equipment which I used in my studies, and he constantly gave me counsel and encouragement.

The topic of translocation was highly controversial during those years. Dixon had proposed that the major transport of assimilates takes place in the xylem; O. F. Curtis of Cornell contended that the phloem conducted not only assimilates but mineral nutrients as well; Mason and Maskell were publishing their masterful work on translocation in cotton; and Münch's book appeared in 1930; J. H. Priestley came to Berkeley in the summer of 1928 and proposed that all nutrients moved from the last differentiated vascular elements in the young stem and root into the meristems probably via the cell walls.

Those of you who have followed the agonizing developments in the field of phloem transport through the years are aware of the many varied mechanisms that have been proposed. When in 1971 I handed Dr. Bennett a copy of Phloem Transport by Crafts and Crisp which has an electron microscope picture of an open sieve plate on its cover, he looked at it for a minute and then said, "That's it." He was keenly aware of the significance of the open sieve plate to transport mechanism and was highly pleased that an acceptable explanation for phloem transport had been found.

Dr. Bennett was more than a graduate student advisor; he involved many of his students in his private life. I recall many luncheons together with Bennett and Matthews at the old True Blue cafeteria on Shattuck Avenue. Especially memorable were those days in 1929 and 1930 when Matthews would tell us how much he had lost as his investments on the stock market fell in value. Bennett always consoled him and advised him to hold on. This he did and later recovered his total losses.

I accompanied Dr. Bennett on his high mountain trips three different summers in the early 1930's. We hiked many miles together with pack sacks on our backs. Mono Pass, Fourth Recess, South Bishop Pass, Muir trail, Evolution Valley. Here I got to know the man as probably few others did. He was honest, discriminating, tolerant, and above all devoted to helping improve the lot of mankind.

We, his graduate students, all owe him a great debt of gratitude for all he gave us during those critical years in our lives.

APPENDIX C.

THE PUBLICATIONS OF
A. S. CRAFTS
1927 - 1978

UNIVERSITY OF CALIFORNIA, DAVIS

1981

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115. Yamaguchi, S. and A.S. Crafts. 1958. Autoradiographic method for studying absorption and translocation of herbicicdes using C^{14}-labeled compounds. Hilgardia 28(6):161-191.

116. Crafts, A.S. and C.L. Foy. 1959. Autoradiography of radioactive dalapon. Down to Earth, 14(4):2-6.

117. Crafts, A.S. and F.M. Ashton. 1959. Current trends in herbicide research. Service 4(2):7-8.

118. Coggins, C.W., Jr. and A.S. Crafts. 1959. Substituted urea herbicides: their electrophoretic behavior and the influence of clay colloid in nutrient solution on their phytotoxicity. Weeds 7:349-358.

119. Yamaguchi, S. and A.S. Crafts. 1959. Comparative studies with labeled herbicides on woody plants. Hilgardia 29(4): 171-204.

120. Crafts, A.S. 1959. Further studies on comparative mobility of labeled herbicides. Plant Physiology 34(6):613-620.

121. Crafts, A.S. 1959. Metabolic interrelations between phloem and xylem. International Botanical Congress, 9th Montreal.

122. Crafts, A.S. and H. Drever. 1960. Experiments with herbicides in soil. Weeds 8(1):12-18.

123. Crafts, A.S. 1960. Evidence for hydrolysis of esters of 2,4-D during absorption by plants. Weeds 8(1):19-25.

124. Crafts, 1960. Pioneering Weed Research. Weed Society of America, Denver, Colorado, February 24.

125. Crafts, A.S. and S. Yamaguchi. 1960. Gross autoradiography of solute translocation and distribution in plants. Medical and Biological Illustration X(2):103-109.

126. Crafts, A.S. and S. Yamaguchi. 1960. Absorption of herbicides by roots. American Journal of Botany 47(4):248-255.

127. Crafts, A.S. 1960. Comparative mobility of tracers in plants. Proceedings 9th International Botanical Congress 2:81-82.

128. Crafts, A.S. 1960. Weed control research--past, present, and future. Weeds 8(4):535-540.

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130. Crafts, A.S. 1961. Translocation of Plants. Holt, Rinehart and Winston, Inc., New York, 182 p. August.

131. Crafts, A.S. 1961. The Chemistry and Mode of Action of Herbicides. Interscience Press, New York, 269 p. June.

132. Crafts, A.S. 1961. Absorption and migration of synthetic auxins and homologous compounds. Encyclopedia of Plant Physiology 4:1044-1054. Springer-Verlag, Berlin. October.

133. Crafts, A.S. 1961. Improvement of growth regulator formulation. Plant Growth Regulation, Iowa State University Press, Ames, 789-802.

134. Crafts, A.S. and W.W. Robbins. 1962. Weed Control, a textbook and manual. McGraw-Hill Book Co., New York, 660 p. (2nd revision by A.S. Crafts.)

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144. Crafts, A.S. 1963. Experiments con herbicidas endifferentes cultiros. X Aniversario del Servicio Shell para el Agricultor, Separata 3:88-95.

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158. Crafts, A.S. 1967. Absorption and translocation of labeled tracers. V. Synthetic Hormones. Annals of the New York Academy of Sciences 144:357-361.

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162. Crafts, A.S. 1967. Water structure and water in the plant body. In: Water Deficits and Plant Growth, Volume I, Chapter 2, p. 23-47, Academic Press, Inc., New York.

163. Crafts, A.S. 1967. Water deficits and physiological processes. In: Water Deficits and Plant Growth, Volume I, Chapter 3, p. 85-133, Academic Press, Inc., New York.

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170. Crafts, A.S. and C.E. Crisp. 1971. Phloem transport in plants. W.H. Freeman & Co., San Francisco, 481 p.

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172. Ashton, F.M. and A.S. Crafts. 1973. Mode of Action of Herbicides. John Wiley and Sons, Inc., New York, 504 p.

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174. Crafts, A.S. 1974. Weed control. 15th Edition, Encyclopedia Britannica, p. 722-727.

175. Crafts, A.S. 1975. Modern aspects of studying water relations in plants. Published in Russian in a journal of Plant Physiology with an English summary. XII International Botanical Congress, Leningrad, 1975.

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177. Crafts, A.S. 1978. History of the Western Weed Control Conference. Typed and xeroxed copies in hands of Western Society of Weed Science. A copy left with Dick Dickman in U.C. Davis library.

APPENDIX D. REPORTS BEFORE SCIENTIFIC MEETINGS

1931	The function of the sieve tube in conduction. American Journal of Botany Supplement 18:5, New Orleans, Louisiana.
1932	Some factors influencing the penetration of herbicides. Pullman, Washington.
1934	Methods employed in the study of weed control in California. Berkeley, California.
1934	The behavior of arsenic and sodium chlorate when used as herbicides in soils. Berkeley, California.
1935	Toxicity and fixing of boron in four California soils. Los Angeles, California.
1936	Toxicity studies on arsenic, borax, and chlorate. Seattle, Washington.
1936	The mechanism of translocation as related to the nutrition of plants. Western Society of Naturalists. Los Angeles, California.
1937	Further studies on chlorate toxicity. Denver, Colorado.
1938	The relation of structure and function of the plant cell wall. San Diego, California.
1938	Chemistry and plant physiology in the service of weed control. American Society of Agronomists and Soil Science Society of America, Washington, D.C.
1938	The relation between structure and function of the phloem. Richmond, Virginia.
1939	Principles of chemical weed control. Second Annual Meeting, Western Weed Control Conference, Berkeley, California.
1939	The mechanism of movement of organic materials in plants. Symposium, Palo Alto, California.
1940	Vascular differentiation in the shoot apex of Sequoia. Seattle, Washington.
1941	Absorption and movement of water in plants. Salt Lake City, Utah.
1945	Herbicidal properties of oils. Eighth Annual Meeting, Western Weed Control Conference, Boise, Idaho.

1946	Uptake of Nutrients by plants. Meeting of the American Society of Plant Physiologists, Western Section, Reno, Nevada. Presided at session.
1947	Sorption of soil fumigants. American Society of Plant Physiologists, Western Section, San Diego, California.
1948	Discussion Leader, Symposium on selective herbicides. American Society for Horticultural Sciences, Cincinnati, Ohio.
1949	New developments in weed control. Twentieth National Turf Conference, The Greenkeeping Superintendents Association, Los Angeles, California.
1949	Chemistry of weed killers. First Annual California Weed Conference, Sacramento, California. In charge of program on research.
1949	The chemistry of weed killers. Sixteenth Annual Meeting of the National Shade Tree Conference, Sacramento, California.
1949	Physiology of weed control. Sixth Annual Meeting, North Central Weed Conference, Sioux Falls, South Dakota.
1950	Weed control. Second Annual Convention, California State Florists Association, Santa Barbara, California. Guest Speaker.
1950	Discussion Leader. Panel discussion on absorption and translocation of herbicides. Second Annual California Weed Control Conference, Pomona. Vice-president.
1951	Arsenic as a soil sterilant. Third Annual California Weed Control Conference, Fresno, California. President of conference.
1951	Chemistry of weed killers, in weed class for commercial operators. Third Annual California Weed Conference, Fresno, California. President of conference.
1951	Air pollution by spray drift and volatilization of hormone herbicides. Joint Symposium American Society of Plant Physiologists, American Phytopathology Society, American Society of Horticulture Sciences, Botany Society of America, Western Society of Naturalists, and Western Society of Soil Science, AAAS Meetings, Los Angeles, California.
1951	Some problems of chemical weed control. Twelfth International Congress of Pure and Applied Chemistry, New York, New York.

1952 Physiology of herbicidal action. Fourth Annual California Weed Conference, San Luis Obispo, California. In charge of program on research.

1952 Relation of pH to the penetration and translocation of 2,4-D in plants. Thirteenth Western Weed Control Conference, Reno, Nevada.

1952 Fundamental nature of plant surfaces. Symposium on the Significance of Pesticide Residues, III. Physical factors in deposition and persistence. American Chemical Society, Milwaukee, Wisconsin.

1952 Absorption and translocation of herbicides. Symposium on the Formulation and Action of Herbicides. 122nd Meeting of American Chemical Society, Atlantic City, New Jersey. Co-chairman of symposium.

1952 The absorption and translocation of herbicides. Symposium on Herbicidal Action of Chemicals. AIBS Meetings, Cornell University, Ithaca, New York. Program chairman for ASPP. Helped organize symposium.

1953 Absorption and translocation of herbicides. Fifth Annual California Weed Conference, San Jose, California.

1953 The translocation of radioactive 2,4-D in plants and its relation to the general problem of translocation. Symposium of ASPP and Botany Society of America, AAAS Meetings, Santa Barbara, California.

1953 Nature of cuticle, mesophyll, xylem, and phloem--and general physiological relationships in plants. Entomological Society of America, Pacific Branch, Lake Tahoe, California.

1953 Translocation of radioactive 2,4-D in plants and its relation to translocation in general. Joint Meeting of the ASPP and the Physiological Section of the Botany Society of America. AIBS Meetings, Madison, Wisconsin. Chairman of joint meeting.

1953 Absorption and translocation of herbicides. First National Weed Control Conference, Kansas City, Missouri.

1954 Progress report on absorption and translocation of herbicides. Sixth Annual California Weed Conference, Sacramento, California.

1954 New evidence for the mass-flow mechanism. VIII International Botanical Congress. Paris, France.

1954 Composition of the sap of xylem and phloem and its relation to nutrition of the plant. VIII International Botanical Congress. Extrait de la Brochure Analyse des Plantes et Problemes des Fumures Minerales, pp. 1-4, Paris, France.

1954 Active water uptake by plant cells. VIII International Botanical Congress, Paris, France.

1954 Use of radioactive isotopes of 2,4-D in brush control. Research Progress Report. Fourteenth Western Weed Control Conference, Tucson, Arizona.

1955 Formulation of herbicides. Seventh Annual California Weed Conference Proceedings, pp. 60-67, Santa Barbara, California.

1955 Where are we headed in chemical weed control? Eighth Conference of Southern California Weed Control Regulatory Officials, Riverside, California.

1955 Relation of phloem structure to the translocation of chemicals. Gordon Conference on Plant Biochemistry and Agriculture, July 27, Kimball Union Academy, Meriden, New Hampshire.

1955 Water loss and water retention by plants. Symposium paper, Western Society of Naturalists, Davis, California.

1956 A research approach to weed control. North Carolina Pesticide School, Raleigh, North Carolina.

1956 Weed Society of America, Denver, Colorado.

1957 A decade of progress in chemical weed control. Western Washington Horticultural Association, 47th Annual Meeting, Fruitland Grange Hall, Puyallup, Washington.

1957 Crafts, A. S., Yamaguchi, S., and Ashton, F. M. Comparative studies on herbicide transport. Research Progress Report, Western Weed Control Conference, Boise, Idaho.

1957 Crafts, A. S. and Sheets, T. J. (Senior Author) Soil toxicity studies with four phenylurea herbicides. Research Progress Report, Western Weed Control Conference, Boise, Idaho.

1957 Yamaguchi, S. and Crafts, A. S. Translocation of 2,4-D in *Zebrina pendula* is greatly affected by growth rate. *Plant Physiology* 32 Supplement XLII, AIBS Proceedings, Stanford, California.

1957 Clor, M. A. and Crafts, A. S.
Comparative translocation of C^{14}-labelled 2,4-D, aminotriazole and urea in cotton plants and subsequent leakage from roots. Plant Physiology 32 Supplement XSIII, AIBS Proceedings, Stanford, California.

1957 Crafts, A. S.
Comparative mobility of labelled herbicides in plants. Fourth International Congress of Crop Protection, Hamburg, Germany.

1958 Crafts, A. S.
Translocation studies with labelled herbicides. Talk and Demonstration, Society for Experimental Biology, New Castle Conference. England.

1958 Yamaguchi, S., Clor, M. A., and Crafts, A. S.
Comparative studies on herbicide transport. Research Progress Report, Western Weed Control Conference, Spokane, Washington.

1958 Crafts, A. S.
The formulation of herbicides, African Weed Control Conference, Victoria Falls Hotel.

1958 Crafts, A. S.
The uptake and distribution of herbicides in plants. Demonstration, African Weed Control Conference, Victoria Falls Hotel.

1959 Crafts, A. S.
New research on the translocation of herbicides. Northeastern Weed Control Conference, Hotel New Yorker, New York, New York, Proceedings pp. 14-17.

1959 Crafts, A. S.
What do we know about wetting agents? Eleventh Annual California Weed Conference, Proceedings, Santa Barbara, California.

1959 Crafts, A. S.
Comparative mobility of tracers in plants. Ninth International Botanical Congress, Montreal, Canada.

1959 Crafts, A. S.
Metabolic interrelations between phloem and xylem. Ninth International Botanical Contress, Montreal, Canada.

1960 Crafts, A. S.
Uptake and distribution of herbicides. Twelfth Annual California Weed Conference, Sacramento, California.

1960 Crafts, A. S.
Weed control research: past, present and future. Program-General Meeting, Third Biennial Meeting of the Weed Society of America, Denver, Colorado.

1960 Crafts, A. S.
Pioneering weed research. Banquet talk, Third Biennial Meeting of the Weed Society of America, Denver, Colorado.

1960 Crafts, A. S.
Relative mobility and redistribution of labelled tracers in plants. Plant Physiology 35 Supplement iii, AIBS Bulletin.

1960 Crafts, A. S.
Organic translocation. Informal Discussion Session C2, C. A. Swanson, Plant Physiology 35 Supplement XV, AIBS Bulletin.

1961 Crafts, A. S.
Improvement of growth regulator formulation. Fourth International Conference on Plant Growth Regulation. Boyce Thompson Institute for Plant Research, Inc. Published by the Iowa State University Press, pp. 789-802.

1961 Crafts, A. S.
Biophysics of herbicide action in weeds and weed control. Section of Agricultural Sciences, Tenth Pacific Science Congress, Honolulu, Hawaii.

1961 Crafts, A. S.
Use of labelled compounds in herbicide research. Symposium on Isotope Applications in the Soil and Crop Sciences, Tenth Pacific Science Congress, Honolulu, Hawaii.

1961 Crafts, A. S.
Further studies of herbicide absorption. Weed Society of America, Fourth Biennial Meeting, St. Louis, Missouri.

1962 Crafts, A. S.
Current research on 2,4-D. Fourteenth Annual California Weed Conference, San Jose, California. Gave paper for Joe Key.

1962 Crafts, A. S.
Expression of results in weed research. Fourteenth Annual California Weed Conference, San Jose, California.

1962 Crafts, A. S.
Movement of herbicides in soils and plants. Western Weed Control Conference, Las Vegas, Nevada.

1962 Oregon Lectures. 4/16 PM, Translocation in plants I, background and theories. 4/17 PM, Translocation in plants II, current research and views. 4/18 PM, Modern tools in botanical research. 4/19 AM, Herbicides absorption and translocation. 4/19 PM, Herbicides chemistry and mode of action. 4/20 PM, Role of herbicides in present day agriculture. Corvallis, Oregon.

1962 Crafts, A. S.
The absorption and translocation of herbicides in plant shoots. Gordon Research Conference, Biochemistry and Agriculture, New Hampton, New Hampshire.

1962 Crafts, A. S.
Keynote Address. Fourth Brazilian Seminar on Herbicides and Weed Control. Km 47, near Rio de Janiero, Brazil.

1962 Crafts, A. S.
Absorption and translocation of herbicides. Lecture before the Department of Agriculture, Santiago, Chile.

1962 Crafts, A. S.
Lecture series before the Servicio Shell, Cagua, Venezuela, commemorating the tenth anniversary of its founding, Chemistry and mode of action of herbicides.

1962 Prasad, R., Foy, C. L., and Crafts, A. S.
Role of relative humidity and solution additives on the foliar absorption and translocation of radio-labelled 2,2-dichloropropionic acid (dalapon). Plant Physiology 37 Supplement XIVI, AIBS Proceedings, Corvallis, Oregon.

1963 Crafts, A. S.
Physiology of herbicide transport in plants. Twentieth Western Weed Control Conference, Portland, Oregon. Symposium: Deposit and Entry of Sprayed Herbicides into Foliage. R. N. Raynor.

1963 Crafts, A. S.
Translocation of herbicides in plants. Two lectures before the Department of Plant Pathology and Physiology, Virginia Polytechnic Institute, Blacksburg, Virginia.

1964 Crafts, A. S.
Taking stock in weed control. Welcoming Address, Sixteenth Annual California Weed Conference, El Rancho Motel, Sacramento, California.

1964 Crafts, A. S.
Moderator for panel, A few key advances in weed control research panel. F. M. Ashton, D. E. Bayer, P. A. Castelfranco, C. L. Foy, O. A. Leonard, D. E. Seaman. Sixteenth California Weed Control Conference, El Rancho Motel, Sacramento, California.

* * *

Crafts: During the sixteen-month tour which my wife and I took following my retirement in June, 1964, I delivered over seventy lectures at various universities and Agricultural Experiment Stations which we visited. There were four titles which I used to designate these lectures: "Absorption and Translocation of Labelled Tracers," "Distribution of Herbicides in Plants," "Methods of Autoradiography," and "Weed Control in California." I used sets of Kodachrome slides to illustrate these lectures. Much of the information delivered in these lectures appears in Autoradiography of Plant Materials by Crafts and Yamaguchi (1964), and in Phloem Transport in Plants published by Crafts and Crisp in 1971. These titles appear in Publications of A. S. Crafts.

APPENDIX E. HONORS AND AWARDS - ALDEN S. CRAFTS

Loughridge Scholarship	1925-27
James Munroe McDonald Scholarship	1927-28
Phi Sigma - Chairman	1927
Gamma Alpha	1927
Phi Beta Kappa	1927
Highest Honors in Agriculture at graduation	1927
Sigma Xi - Associate Member	1928
NRC Fellowship, Cornell University	1930-31
Sigma XI - Full Member (Alpha Chapter)	1931
American Society of Plant Physiology, Western Section - Secretary	1938
American Society of Plant Physiology, Western Section - Vice-chairman	1939
American Society of Plant Physiology, Western Section - Chairman	1940
Guggenheim Fellow	1938
Grant-in-Aid, Puerto Rico Experiment Station	1947-48
AAAS Fellow	1948
Travel Grant Lectureship, JD	1949
California Weed Control Conference - President	1950-51
International Botanical Congress, Paris - Delegate	1954
Gordon Research Conference - Vice-chairman	1955
American Society of Plant Physiologists - President	1955-56
Guggenheim Fellow	1957
Fulbright Grant	1957-58
M.S. degree by decree, Oxford University	1957-58
IX International Plant Protection Congress, Hamburg, Germany	1957
Who's Who	1958-59
Royal University, Belgium - Gent Lecture #1	1958
Weed Science Society of America - President	1959-60
Travel Grant, Tenth Pacific Science Congress, Honolulu, Hawaii	1961
Charles Reid Barnes Life Member, ASPP	1962
Servicio Shell, Venezuela Lectureship	1962
Popovich Institute Grant Lectureship, Corvallis Oregon	1962
Honorary Member, WSSA	1964
Alden S. Crafts Alumni Memorial Scholarship	1964
Honorary Member, Zoological-Botanical Society, Vienna, Austria	1965
FAO-IAWA Symposium, Vienna, Austria - Delegate	1965
Sigma XI Annual Convention, Berkeley, California - Delegate	1965
AIBS - Life Member	1966
Cal Aggie Alumni Association - Life Member	1966
LLD Honorary degree, University of California, Davis	1966
University of North Dakota Lectureship	1966
Award of Excellence, WSSA (journal paper)	1967
Honorary Membership - Western Society of Weed Science	1968
IUPAC Symposium Travel Grant, Johannesburg, South Africa	1969

APPENDIX E. HONORS AND AWARDS - ALDEN S. CRAFTS (continued)

Golden Society Member, University of California, Davis	1978
Sigma Xi Emeritus Member	1980
Quarter Century Club, 50 year Member	1981

APPENDIX F. LETTERS OF COMMENDATION

UNIVERSITY OF PUERTO RICO
AGRICULTURAL EXPERIMENT STATION
RIO PIEDRAS, PUERTO RICO

OFFICE OF THE DIRECTOR

May 15, 1948

Dr. A. S. Crafts
Agricultural Experiment Station
Rio Piedras, Puerto Rico

Dear Professor Crafts:

On the termination of your duties at the Agricultural Experiment Station of the University of Puerto Rico, at which you have spent your sabbatic leave since July of last year, I wish to express the deep appreciation of our Institution for the valuable services you have rendered us in studying the weed problems of the Island and in devising effective control measures by chemical means.

You have really pioneered this field in Puerto Rico and I am sure that by your work and your personal contacts with the growers interested in this problem you have given initial momentum to the progress that we are bound to make along these lines in the years to come.

Your interest in the betterment of our technical staff and your frequent counsel on staff problems will be always highly appreciated. The association of all of us with you and your family has been most pleasant and will be long remembered.

Sincerely yours,

Arturo Roque
Arturo Roque
Director

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF PLANT INDUSTRY, SOILS, AND
AGRICULTURAL ENGINEERING

DIVISION OF
CEREAL CROPS AND DISEASES

REPLY TO:

State College
Brookings, South Dakota
March 8, 1949

Dr. A. S. Crafts
Botany Department
College of Agriculture
Davis, California

Dear Dr. Crafts:

I want to first thank you for so kindly sending me reprints of the several publications that you have had recently on the use of herbicides. Your outstanding work on these herbicides is so different from anything that anyone is doing in this area that we are always anxious to get your latest ideas and findings. As you know, I get out an occasional news letter to research cooperators in our NCWCC and your articles and notes are always of prime interest to the men in this area. I will always welcome any notes or news items that you can furnish me for these occasional news letters and assure you that they will be well received in this North Central area.

You will note in the recent copy of the news letter under date of March 2, copy of which was sent to you earlier, that we made reference to several articles which you have recently published and requests for which will undoubtedly be forthcoming from those who received this news letter. I realize that in listing your references that we are imposing on you a large number of additional requests for reprints and I trust that you will not resent this imposition.

With kindest personal regards I am,

Sincerely yours,

LMStahler.

L. M. Stahler
Agronomist

LMS:rmw

CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA
4

KERCKHOFF LABORATORIES
OF BIOLOGY

June 4, 1951

Dr. Alden S. Crafts
University of California
Davis, California

Dear Alden:

I have just read your review in the April issue of the Botanical Review and wish to congratulate you on it. It certainly is high time that we have a review of this kind, an extensive, critical, thorough and modern review of work on Translocation. I suppose this will be the definitive work on Translocation for a long time to come. It has been a real contribution to plant science and one which we all appreciate your having done.

With kindest regards,

Sincerely,

James Bonner

JB/ac

LOS ANGELES: COLLEGE OF AGRICULTURE
DIVISION OF FLORICULTURE AND
ORNAMENTAL HORTICULTURE

July 5, 1951

Dr. A. S. Crafts
Professor of Botany
University of California
Davis, California

Dear Dr. Crafts:

Many thanks for the reprint of your article from the April issue of the "Botanical Review."

I have spent some time going through this in detail and am greatly pleased to note the critical nature of your review. So often the review articles are merely a compilation of abstracts, without any real attempt to evaluate or correlate the material presented. With the vast mass of literature which is being accumulated in most fields, I wish to express the wish that more reviewers would take your approach to the problem.

Sincerely yours,

V. T. Stoutemyer

VTS/c
V. T. Stoutemyer

UNIVERSITY OF CALIFORNIA—(Letterhead for interdepartmental use)

December 18, 1953

Dr. Robert Gordon Sproul, President
University of California
Berkeley, California

Dear Dr. Sproul:

Dr. A. S. Crafts is an internationally recognized authority on translocation and water relations in plants. In addition, he is known as the "father of chemical weed control" in this country.

I have known Dr. Crafts for twenty years and have the highest regard for his knowledge and integrity.

I feel that his proposed visit to European institutions will add to the furtherance of Dr. Crafts' plant physiological projects and thereby will add to the resources of knowledge of the University of California.

Very truly yours,

J. van Overbeek, Head
Plant Physiology Department

JvO:pd

UNIVERSITY OF CALIFORNIA

OFFICE OF THE DEAN
COLLEGE OF LETTERS AND SCIENCE
DAVIS, CALIFORNIA

March 18, 1954

Professor A. S. Crafts
Department of Botany
University of California
Davis Campus

Dear Professor Crafts:

This letter is to congratulate you upon your selection as Faculty Research Lecturer. It is a great honor to be so selected by the faculty; it is an honor eminently merited by your long and distinguished research career.

I am taking this method of extending felicitations, since unexpected and regrettable circumstances, over which I have no control, will prevent the presence of Mrs. Young and myself at the lecture itself and at the preceding and succeeding festivities in your honor.

Sincerely yours,

H. A. Young

THE AMERICAN JOURNAL OF BOTANY
DEPARTMENT OF BIOLOGICAL SCIENCES
STANFORD UNIVERSITY
STANFORD, CALIFORNIA

OFFICE OF THE EDITOR

May 18, 1954

Dr. A. S. Crafts
Department of Botany
University of California
Davis, California

Dear Dr. Crafts:

Thank you for your careful and helpful reviews of the two papers by K. N. H. Greenidge.

I am grateful to you for your help in this matter and I am sure that the author will be equally grateful. I am writing especially to express my appreciation of your willingness to sign your review as you have done in the past. This takes a very large amount of professional responsibility and courage, for which I compliment you.

Sincerely yours,

WC Steere

William C. Steere
Editor

WCS:ch

AGRICULTURAL RESEARCH COUNCIL

Hon. Director:
Professor R. L. Wain, D.Sc., F.R.S.

Telephone: Wye 401

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Your ref.

PRIVY COUNCIL

PLANT GROWTH SUBSTANCE & SYSTEMIC FUNGICIDE UNIT.
Wye College,
Near Ashford, Kent.

6 December, 1962

Dr. A. S. Crafts,
Chairman, Department of Botany,
University of California,
Davis, Calif.

Dear Dr. Crafts,

We arrived back in England yesterday to find one of the worst fogs for many years and we had some difficulty in getting to Wye from Southampton. This was a somewhat different environment from what we had been experiencing in California!

I must say that altogether our trip was most interesting and enjoyable but one of the high spots was certainly our stay with you at Davis. You and your wife could not possibly have been nicer and we greatly appreciated the kindness and hospitality you extended to us. We shall long remember our visit to Grass Valley, to the 'Nut tree' and to the overseas students' luncheon and all the other interesting things we did with you.

Thank you again for everything. With kindest regards,

Yours sincerely,

R. L. Wain

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
CROPS RESEARCH DIVISION
BELTSVILLE, MARYLAND 20705

April 15, 1964

AIRMAIL

Dr. A. S. Crafts
Department of Botany
University of California
Davis, California

Dear Dr. Crafts:

I know your many friends in the scientific world share the news of your retirement with mixed emotions. Sadness in the knowledge that there can never be a replacement, but with joyous pride in the great good that you and Mrs. Crafts have contributed to all mankind.

As Weed Scientists we share a more intimate relationship. For in truth, we are all students of your teaching, research, and philosophy. This philosophy is fortunately recorded in your many technical publications and textbooks as memorials to your extraordinary accomplishments which will live as long as history.

As one who has been privileged to know you and your family, I am grateful for your leadership in the establishment of Weed Science as a scientific discipline which scientists can embrace with professional pride and honor in the future.

We regret that we can not be with you on the occasion of your retirement, but we want you to know we are thinking about you. As you and Mrs. Crafts begin a new way of life, my family joins me in sending our congratulations on your retirement and extend our personal good wishes for a happy and productive future.

Most sincerely,

Warren

W. C. Shaw
Leader, Weed Investigations - Agronomic Crops
Crops Protection Research Branch

Silver Spring, Maryland

April 15, 1964

Dear Dr. Crafts:

This letter is written because I am unable to attend the dinner given in your honor. Nevertheless, this occasion gives me the opportunity to express deep and heart-felt thoughts about you, a man who I (and many many others) have been privileged to have had as professor and friend.

It is an honor for one to refer to you as their former professor. The ancient Greeks believed that the greatest tribute was for one to say, "He was my teacher".

The students are innumerable that have passed through your hands, and each of us owes you a great debt for our scientific knowledge and aid for our personal recognition and placement.

Many are we who have bothered you with the need of reference letters. Not once have I heard of you being irked or weary of this cumbersome task. It was your gratification to promote us to the utmost of your ability.

You have inspired and instilled interest and faith in the scores who have relied on you. You have given unselfishly as a scientist, teacher, individual and friend.

Your scientific achievements are neither forgotten nor overlooked, but you have gained recognition as a scientist in this country as well as abroad. However, this is the time for us to pay homage to you as a teacher.

Your insatiable energy in all your undertakings -- science, teaching and personal -- shall always be remembered. You are the beacon light which we, your students, will use as a source for the remaining of our lives. We hope to be able to impart some of the rays of this light to the future.

So that I may demonstrate, in my meager, small way, my esteem and gratitude, I have pledged to support the A. S. Crafts Fund.

Before closing, I would like to write a few words concerning that grand and gracious lady, Mrs. Crafts, who opened her home and heart to many of us. Students and spouses from all parts of the world are grateful to both

-3-

of you and recognize the asset you have been to each other.

My family and I wish you well in this new phase of life.

With great admiration, respect and affection; I remain

Very truly yours,

Elias D. Dekazos

MAATALOUDEN TUTKIMUSKESKUS
KASVINVILJELYLAITOS
5.8.1970
No

Dr. A. S. Crafts
Botany Department
University of California
Davis, Calif. 95616
USA

Dear Dr. Crafts:

I have been pleased to receive your publication The Autoradiography of Plant Materials with personal compliments. I am also grateful to you for keeping company with me during the FAO Conference. I certainly enjoyed your company and feel proud having the opportunity of associating with the greatest pioneer in weed science.

I can imagine how enormous amount of work you have done in preparing this and other books, in carrying out your own basic research, collecting material from all ower the world, carefully selecting and classifying the material and finally making successful synthesis. Your accomplishments are highly appreciated by the present weed scientists, and they certainly will be appreciated by the future scientists as well.

I wish you many, many successful years of active writing. Enclosed I am sending you a seminar paper on History and Recent Development of Weed Science in Scandinavia. Please, accept this paper as a small souvenier from your most truly admirer.

Sincerely yours,

Jaakko Mukula
Director

JM/re

MAATALOUDEN TUTKIMUSKESKUS
KASVINVILJELYLAITOS
Tikkurila 5.8.1970
No

Dr. A. S. Crafts
Botany Department
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Davis, Calif. 95616
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Sincerely yours,

Jaakko Mukula

Jaakko Mukula
Director

JM/re

Institut de la Recherche Agronomique
Service des cultures
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Adr: TIKKURILA
FINLAND

Agricultural Research Centre
Department of Plant Husbandry

Zentrale für Landwirtschaftliche Forschung
Abteilung für Pflanzenbau

APPENDIX G. CONSULTING EXPERIENCES

As soon as chemicals were introduced in control of weeds, problems of misuse, ignorance and lack of care in application became apparent. When the railroads started spraying rights-of-way with sodium arsenite solution, cases of losses of cattle and sheep occurred. Although the areas were supposed to be fenced, there were cases where the attractiveness of the sprayed vegetation to cattle led to breaking down of fences and to cattle losses. Thousands of law suits against the railroads occurred.

Soon after introduction of 2,4-D in 1945, injury to non-target crop plants appeared and it soon became apparent that 2,4-D was carried by volitilization or spray drift to crops on adjacent fields and, because people were not familiar with the symptoms of 2,4-D injury or the factors responsible, expert advice was needed, particularly if the case was brought to court. It was cases of this sort that I was asked to help with.

Many cases of 2,4-D injury were brought to my attention. One early one, north of Woodland, involved a field of tomatoes which was exposed to drift from spraying rice fields, north of the tomatoes. Drift from the rice passed over the tomatoes while they were blooming and the fruits developed rapidly, matured early, and proved to be seedless. When these fruits were picked and loaded into trucks, the lack of firm structure resulted in the fruits settling and bursting and the juice leaked to the ground to the extent that one truck became stuck in the mud. Examination of the field proved that willow and walnut trees along a canal bank on the north side of the tomato field, were chlorotic on their north sides, evidence of exposure to 2,4-D drift. There were also misformed leaves on the tips of the tomato plants and on weeds in the field, characteristic of hormone exposure. We in plant physiology were familiar with these symptoms and we were able to help the farmers and the County Agricultural Commissioners to identify the cause.

Later, I was called in to identify 2,4-D symptoms on tomatoes in areas north of Sacramento, on pea crops near Davis, and on cotton in the Tulare Lake District in the San Joaquin Valley.

An interesting case involved loss of an onion crop near Hollister in San Benito County. The field had been sprayed with Fenac, pre-plant, which controlled weedy grasses in the emerging crop. But broad-leaved weeds were not controlled and these were sprayed with Dow selective herbicide with excellent results. Soon, there was a strong north wind which carried enough sand to cut the young onion plants off at the soil surface. The onion plants survived this injury and young leaves emerged from the cut-off plants and grew. But, with irrigation, a new crop of broad-leaved weeds grew and threatened the onion crop. The custom sprayer, who had supervision of pest control in the crop, not realizing how sensitive these young new onion leaves were, resprayed with Dow selective. Whereas the original onion coleoptiles were cutinized and able to stand this selective dinitro spray, the young newly emerged leaves were not, and the crop was ruined. Here, good training in plant science provided an answer where the experience of the custom sprayer did not cover the situation. My next 2,4-D experience involved a sugar beet crop which showed no signs of 2,4-D exposure until they were harvested. These beets occupied a long strip of land along a tributary to the Snake River in Idaho. The field away from the gorge of the tributary was planted to wheat, and it was sprayed with 2,4-D on a Sunday when the air was still as indicated by smoke from burning tires. As mentioned, the sugar beet crop as observed from the roadside seemed perfectly normal. However, when they were lifted they proved to have multiple crowns. Now the sugar refineries had just made a rule that the crown tissue would be eliminated in the payment for the beets and this field was heavily penalized for having nearly 50 percent crown tissue and so payments were much below the expected amount.

I was asked to consult on the case, and having agreed to do so, was flown to the field in Idaho. Inspection soon led to a logical explanation. As mentioned, the beet field lay along side the gorge of a tributary of the Snake River, which was very deep. Along the banks of this gorge were cottonwood and black walnut trees, the sides next to the beet field of which were chlorotic, indicating drift of 2,4-D.

While the smoke indicators in the sprayed wheat field indicated no wind blowing toward the beets, as the evening came on and the air in the gorge cooled down, by simple convection there were set up currents across the beets from the wheat field into the gorge. In the process, 2,4-D was drawn across the young beet plants resulting in activation of the buds in the axils of the young leaves and the development of several rigorous shoots on each plant in place of the single dominant shoot normally present.

When I finished my inspection of this situation, I went home and wrote a detailed explanation which I submitted to the Swiss Insurance Company who had carried insurance of the manufacturers of the 2,4-D. As soon as they received this logical explanation they sent me a check covering my fees.

I have consulted in two cases of 2,4-D injury to lettuce fields. One was on a field bordered by Highway #5 near Kettleman City in the San Joaquin Valley. On one side of Highway #5 was a large barley field, on the other side, the lettuce field. When the company growing the lettuce started harvest it was apparent that many heads were soft and springy, some were tall and tapering, "Christmas trees", and none were marketable. I was flown from Fresno to this field and again it was very apparent that when the barley field was sprayed with 2,4-D to control wild mustard, there had been drift across the young lettuce plants and that the hormone effect upon the suppressed apical dominance of the lettuce had released the dormant axillary buds and that young shoots were developing, loosening the head and giving rise to the tall tapering bunches. Also, weeds along the ditches and road sides in the lettuce field showed typical fan-shaped leaves and other formative effects characteristic of 2,4-D exposure.

The second case of lettuce injury occurred in Alamosa, Colorado. Here, a small valley which had produced barley crops for years, had been the site of a dam built by the Army Engineers to provide water for irrigation. A Salinas vegetable growing company found that this valley was ideal for growing lettuce to fit between the Imperial and Salinas Valley crops. They planted lettuce in many fields across this valley, not taking into account that the barley growers customarily sprayed their fields to control the wild mustard.

Again, when I inspected these lettuce fields I found "Christmas tree" heads, soft heads, and a general condition indicating exposure of the young plants to 2,4-D. Again there were 2,4-D symptoms on several species of weeds.

This situation is still under litigation and the trial will take place in March, 1982.

I have had experience with two cases of 2,4-D injury to grapes. One involved a vineyard of the Sebastiani Company in Shellville, California. Here young vines in a new vineyard were injured, some to the extent of death. The problem was to identify the offending parties. Dairymen, utilizing hill pastures in Sonoma County, customarily spray in the spring to suppress thistles. As a result of this, all grape vines in the Shellville area show mild symptoms. On the other hand, highway maintenance crews in the area occasionally spray roadsides with a heavy dose of 2,4-D to kill bindweed, chickory, chinese lettuce, and other weeds. When I examined the Sebastiani vineyard and found dead vines, I was certain that it was the application along the highway bordering the vineyard that had caused the damage.

The other case was located in vineyards south of Auckland, New Zealand. A lawyer, by the name of Williams, was hired by a grower, a spray plane operator and a chemical company who were defendants in a suit brought by Montana Vineyards who were seeking payment for injury to their vines. I was asked by Mr. Williams to serve as consultant to prove, if possible, that his constituents were not responsible. I was flown to New Zealand for consultation in May of 1976. With Mr. Williams I surveyed the situation. The grapes were growing on the edge of a large valley with a tributary of the main stream coming in above the grapes. The spraying had been done to kill thistles in a flat area of pasture six miles up the tributary from the vineyard.

The spraying had been done in 1970 and the vineyards had just filed the suit; the only available evidence consisted of a number of kodachrome slides showing rather severe symptoms, fan shaped veining of leaves, shortened shoot tips, and shot-berry grapes--all symptoms of severe damage from a heavy exposure.

After examining the situation and planning the approach to the defence of the case, I returned to Davis and gathered published materials on 2,4-D injury as experienced in California. I was convinced that the damage was entirely too severe to have been caused by thistle spraying, six miles away. All pastures in New Zealand are sprayed for thistles every year. Undoubtedly, someone much closer had caused the damage. The case here was exaggerated by the fact that the spraying had been done using a helicopter and everyone in the district had been aroused by the noise.

My wife and I had planned to attend the trial in early June and afterward to take an extensive tour around both islands. We had made all arrangements for this when, two days before our departure, a phone call announced that the case had been settled out of court.

We took our tour anyway. The settlement of the case was interesting. I was certain that I could convince the court that Montana Vineyards were sueing the wrong people. But the lawyers were able to alter the whole situation. Despite the fact that, as claimed by Montana, production had been reduced to fifty percent of normal, the vineyards produced and sold as much wine as in any other year. By examining the official records, the lawyers brought out this fact and as soon as it came out in court that sales had not been reduced, Montana sued to settle out of court. They evidently didn't want it known that they were making wine out of water.

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